

# The description and osteology of a new species of *Gephyroglanis* (Siluriformes, Bagridae) from the Olifants River, South West Cape, South Africa

by

P. H. SKELTON

(Albany Museum, Grahamstown, 6140, R.S.A.)

## CONTENTS

	<i>Page</i>
Abstract .....	218
Introduction .....	218
Methods .....	218
Description of <i>Gephyroglanis barnardi</i> sp. nov. ....	220
Material examined .....	220
Diagnosis .....	220
Comparison with <i>Gephyroglanis gilli</i> and <i>G. sclateri</i> .....	225
Distribution, habitat preferences and status .....	225
Etymology .....	227
Osteology .....	227
Neurocranium .....	227
Infraorbitals and nasal bones .....	232
Suspensorium, palatine-maxilla and preopercular .....	232
Opercular Series .....	235
Lower jaw .....	235
Hyoid arch .....	235
Branchial skeleton .....	237
Pectoral girdle .....	239
Weberian apparatus .....	239
Precaudal vertebrae .....	242
Caudal vertebrae .....	242
Caudal skeleton .....	242
Dorsal fin skeleton .....	242
Pelvic fin skeleton .....	243
Anal fin skeleton .....	243
Discussion .....	245
Acknowledgements .....	248
References .....	249

## ABSTRACT

A new small bagrid catfish referred to *Gephyroglanis* is described from the Olifants River, western Cape Province, South Africa. The osteology of the new species is described and figured. Comparisons with other South African *Gephyroglanis* species are drawn and queries concerning the generic placement of these species are raised.

## INTRODUCTION

The Olifants River system in the south-western Cape Province (Fig. 7) has a particularly high proportion of endemic fish species. One of these, *Gephyroglanis gilli* Barnard, 1938, is a relatively small bagrid catfish. A second *Gephyroglanis* species, *G. sclateri* Boulenger, 1901, occurs in the Orange River system to the north. Other *Gephyroglanis* species, found in the Zaire River and in rivers of West Africa (Boulenger, 1911; Jayaram, 1966), are remote from the southern African species.

Barnard (1943) commented on the intraspecific variation of both southern African *Gephyroglanis* species pointing out that two rather distinct "fin forms" are found: one with a high ragged dorsal fin and the other with a low dorsal fin. Barnard *op. cit.* (p. 229) remarked that if the extremes of each form were taken from different river systems they could "almost be regarded as constituting a specific difference". He considered, however, that the differences were phenotypic in nature, the high fin form coming from rocky, flowing waters and the low fin form from placid, muddy waters.

During routine identification of fishes from a survey of the Olifants River system conducted by the Department of Nature and Environmental Conservation, the author was impressed by the remarkable difference of fin form between specimens of *Gephyroglanis*. Further investigations revealed that the differences of fin form were correlated with other characters which, contrary to Barnard's finding, indicated specific distinction. Re-examination of existing collections revealed that several, including the syntype series of *G. gilli*, contained two clearly different species of which one is referable to *G. gilli* and the other is here described as new.

## METHODS

Measurements were taken to the nearest 0,1 mm and are expressed as percentages of standard length.

Linear measurements (Fig. 1) were made according to Hubbs & Lagler (1958) except for the following:

*Pectoral to pelvic fin length* is the median measurement between the posterior margins of the bases of the pectoral and pelvic fins.

*Pelvic to anal fin length* is the median measurement between the posterior margin of the base of the pelvic fin and the base of the first anal fin ray.

*Predorsal length* is measured from the symphysis of the premaxillae to the base of the first dorsal fin spine.

*Humeral process length* is measured from the base of the pectoral spine to the tip of the humeral process.

Vertebral counts were determined from radiographs. Counts were taken according to Skelton (1976).

Anal fin rays were counted as far as possible by dissection. The number of anterior unbranched rays is nevertheless difficult to determine accurately because these rays are fine and small. Completely reliable counts are available from six cleared and stained specimens.

Specimens were cleared and stained for bones and cartilage using Taylor and Van Dyke's (1979) modified trypsin method (Alcian blue for cartilage, alizarin red for bone).

SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS

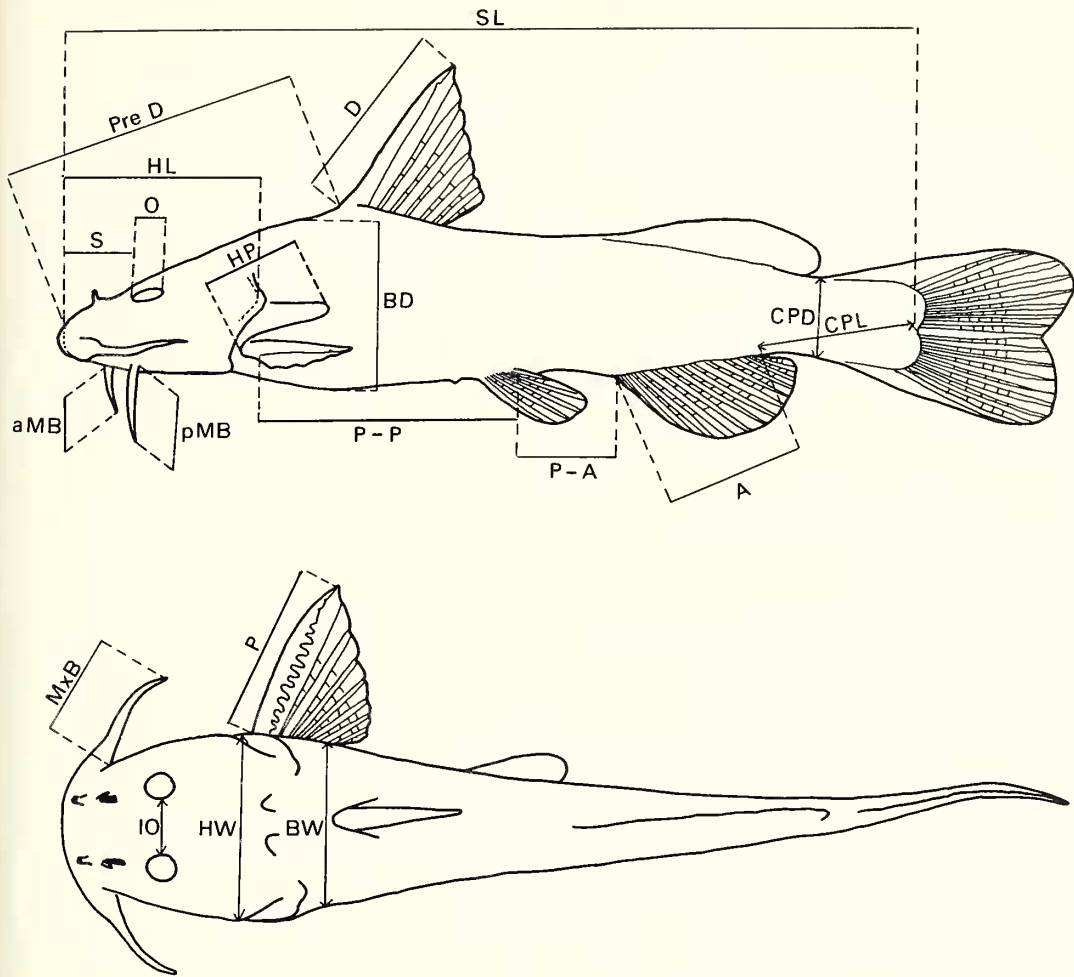


Fig. 1. Measurements as made in this study on *Gephyroglanis*.

Abbreviations: A—anal fin base; aMB—anterior mandibular barbel; BD—body depth; BW—body width; CPD—caudal peduncle depth; CPL—caudal peduncle length; D—dorsal fin length; HL—head length; HP—humeral process length; HW—head width; IO—inter orbit; MxB—maxillary barbel; O—orbit diameter; P—pectoral fin length; P-A—pelvic to anal fin; P-P—pectoral to pelvic fin; pMB—posterior mandibular barbel; Pre D—predorsal length; S—snout length; SL—Standard length.

Abbreviations: AM/P—Albany Museum fish collection, Grahamstown; BMNH—British Museum (Natural History), London; MNHN—Muséum National d'Histoire Naturelle, Paris; MRAC—Musée Royal de l'Afrique Centrale, Tervuren; USNM—United States National Museum (specimens in National Museum of Natural History, Smithsonian Institution), Washington; RUSI—J. L. B. Smith Institute of Ichthyology, Grahamstown; SAM—South African Museum, Cape Town.

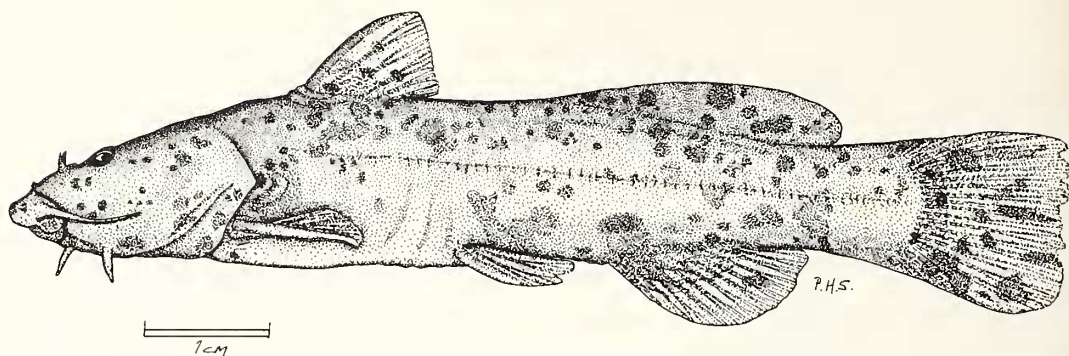


Fig. 2. Holotype of *Gephyroglanis barnardi* sp. nov., male of 68,5 mm SL. AM/P 7647 (a)

## DESCRIPTION

*Gephyroglanis barnardi* sp. nov.

Barnard's rock catlet (Fig. 2)

### Material examined

Holotype: AM/P 7647 (a) ♂ 68,5 mm SL. Noordhoeks River at roadbridge, tributary of Olifants River, Cape Province, S.A. (32° 43' 15"S; 19° 03' 59"E). Electrofished by K. Hamman & S. Thorne, 3 September 1979.

Paratypes: 3, AM/P 7647 (b) 71 mm SL; 57,4 mm SL, 51,5 mm SL. Collected together with holotype. 29, (ex) AM/P 1369 33,5–67,2 mm SL. Collected at same site as holotype by F. L. Farquharson, 7 April 1967. (5 specimens sent to BMNH, 5 to USNM, 5 to MNHN). 14, AM/P 1879 (4 cleared and stained). Collected at same site as holotype by K. van Rensburg, 17 March 1965. (5 specimens to RUSI). 7, AM/P 893 (2 cleared and stained). Collected at same site as holotype by K. van Rensburg, 17 March 1965. 7, SAM 29232. Collected by K. H. Barnard and C. W. Thorne, Noordhoeks River and Olifants River mainstream at Keerom, February 1939, (ex-type series of *G. gilli*).

Other Material: 1, AM/P 8202, ripe 74,5 mm SL. Noordhoeks River at roadbridge. Electrofished by P. H. Skelton and S. Thorne, 6 January 1981. 1, AM/P 8206, ripe 5 mm SL, Thee River (32° 47' 49"S, 19° 05' 31"E). Electrofished by P. H. Skelton and S. Thorne, 7 January 1981.

### Diagnosis

*G. barnardi* is relatively small, the longest specimen examined is 75 mm SL. Morphometric proportions recorded in Table 1. Head depressed and flat with squarish profile from above, 6,6 to 8 times in SL, broadest at level of the opercle, dorsal surface entirely covered by skin. Angle of head shallow (20–30°) rising straight or with a very shallow arch to the nape and dorsal fin. Eyes dorso-lateral, small, directed dorsally and widely spaced; mouth straight, sub-terminal with moderately papillose and fleshy lips.

Nares widely separate, located antero-medial to orbits; anterior short and tubular, posterior elongated. Each posterior naris bordered in front with a short compressed barbel (Fig. 4) the base of which extends posteriad as a low narrow ridge on either side of the naris. Snout bluntly curved.



SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS

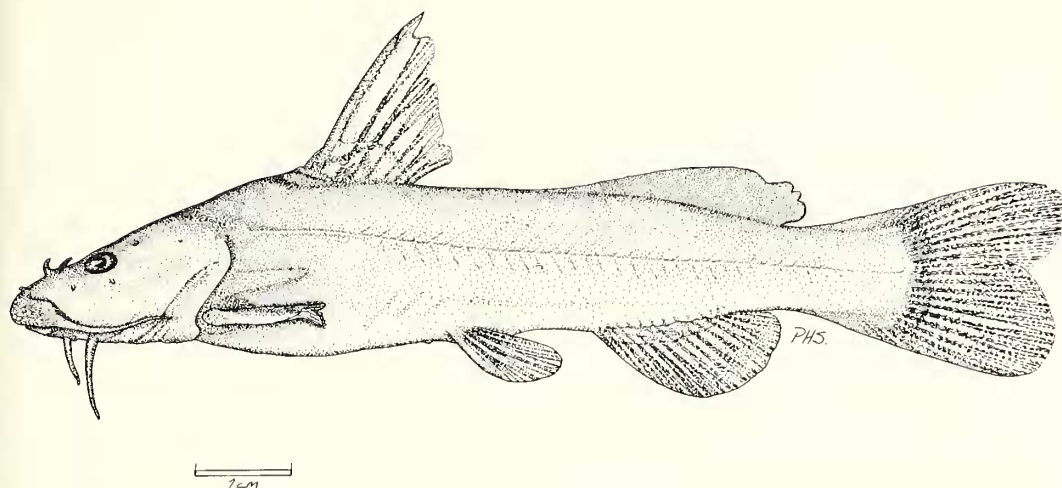


Fig. 3. *Gephyroglanis gilli* Barnard, male of 97,4 mm SL. AM/P 7646 collected in same locality as holotype of *G. barnardi*.

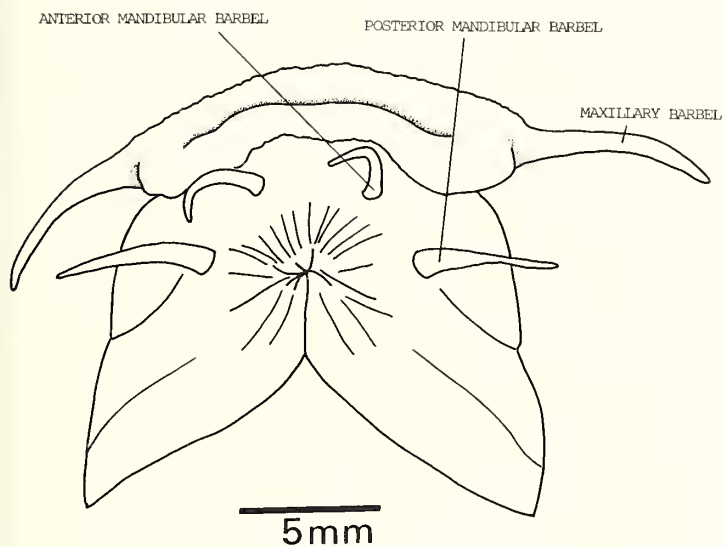


Fig. 5. Ventral view of head of holotype of *G. barnardi* sp. nov. to show mouth form and position of mandibular barbels.

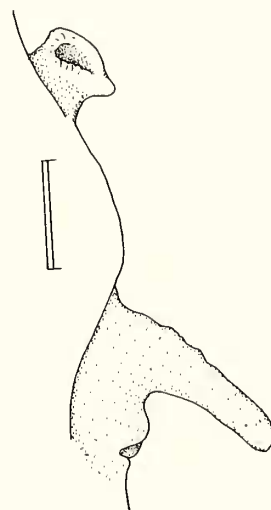


Fig. 4. Left lateral view of nares and nasal barbel of holotype of *G. barnardi* sp. nov. Scale bar = 1 mm.

TABLE 1.  
Comparative measurements (%SL) of southern African Gephyroglanis species: *G. barnardi* holotype and paratypes; *G. gilli*—AM/P 1369; *G. sclateri* AM/P 3921 (3), 1477 (8), 1383 (7). Measurements of holotype in mm.

	<i>G. barnardi</i>						<i>G. gilli</i>						<i>G. sclateri</i>					
	Holotype	Min	Max	M	SD	SE	Min	Max	M	SD	SE	Min	Max	M	SD	SE		
Head length.....	25.3	24.0	27.1	25.5	0.7	0.1	19.5	28.6	25.8	1.8	0.4	23.3	26.7	25.0	0.8	0.2		
Head depth.....	14.6	12.8	15.5	14.0	0.7	0.1	12.9	15.81	14.3	0.8	0.2	11.1	16.3	14.4	1.2	0.3		
Head width.....	22.5	19.4	23.3	21.5	0.9	0.1	19.6	22.9	21.3	1.0	0.2	18.7	22.2	20.8	0.9	0.2		
Orbit.....	2.8	2.8	3.9	3.5	0.2	0.03	3.4	5.3	4.2	0.6	0.1	3.2	5.0	4.2	0.5	0.1		
Interorbit.....	8.5	6.6	9.5	8.2	0.7	0.1	6.3	7.8	7.3	0.5	0.1	7.4	8.9	8.1	0.4	0.1		
Snout.....	10.5	9.8	11.5	10.5	0.4	0.1	9.6	12.4	11.0	0.7	0.2	11.0	13.1	11.8	0.7	0.2		
Body Depth.....	19.0	14.7	19.4	16.6	1.1	0.2	15.3	20.8	18.1	1.3	0.3	17.1	24.4	20.5	1.8	0.4		
Body Width.....	18.7	16.4	20.1	18.3	0.8	0.1	16.9	20.4	18.8	0.9	0.2	17.2	21.1	19.5	1.1	0.2		
Caudal Peduncle Length.....	20.4	18.5	23.2	20.5	1.1	0.2	14.7	20.8	17.7	1.6	0.4	16.2	21.4	18.5	1.3	0.3		
Caudal Peduncle Depth.....	11.2	8.7	11.3	10.0	0.6	0.1	8.4	10.0	9.0	0.4	0.1	8.9	10.5	9.9	0.4	0.1		
Dorsal Fin Height.....	17.1	14.3	18.8	16.9	1.0	0.1	19.1	25.5	21.4	1.8	0.4	17.1	24.0	21.0	1.8	0.4		
Pectoral Fin Length.....	17.2	16.3	20.1	17.9	1.0	0.2	17.1	23.7	20.2	1.8	0.4	15.4	20.3	18.1	1.2	0.3		
Pelvic Fin Length.....	13.4	10.7	16.7	12.5	1.0	0.1	10.1	14.9	12.3	1.2	0.3	10.7	15.6	12.3	1.2	0.3		
Base of Anal Fin.....	17.2	14.7	20.5	17.3	1.0	0.2	13.8	18.7	15.9	1.2	0.3	13.6	18.2	15.7	1.5	0.3		
Maxillary Barbel.....	9.3	7.9	12.8	9.8	1.2	0.2	8.5	16.1	12.4	2.0	0.4	7.3	11.9	9.2	1.1	0.3		
Anterior Mandibular Barbel.....	5.8	4.4	6.8	5.5	0.6	0.1	4.2	8.1	6.3	1.2	0.3	2.7	5.3	4.5	0.7	0.2		
Posterior Mandibular Barbel.....	8.0	6.3	10.7	8.7	1.0	0.1	7.5	14.9	10.5	2.0	0.5	4.4	10.7	8.1	1.3	0.3		
Pectoral—Pelvic Length.....	25.4	21.5	26.6	24.3	1.1	0.2	20.9	26.1	23.7	1.4	0.3	22.3	27.3	24.8	1.5	0.3		
Pelvic—Anal Length.....	15.0	13.4	18.2	15.5	1.3	0.2	11.1	17.8	14.3	1.5	0.3	12.7	17.8	15.1	1.4	0.3		
Predorsal Length.....	32.7	30.9	34.8	32.6	0.9	0.1	32.4	37.2	34.7	1.3	0.3	32.8	37.4	34.9	1.3	0.3		
Humeral Process.....	6.6	5.0	8.7	7.0	0.8	0.1	10.0	14.2	12.3	1.1	0.3	9.3	11.1	10.2	0.6	0.1		

# SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS

Gill openings continuous ventrally and ascending on either side to the dorso-lateral surface of head. Branchiostegal membranes free. Branchiostegal rays 6-6 (N 6).

Four pairs of barbels present including the short nasal pair described above, a pair of simple maxillary barbels and two pairs of simple mandibular barbels. Maxillary barbels extending lateral from upper jaw, not reaching beyond posterior opercular groove. Anterior mandibular barbels placed ventrally just posterior to lower lip (Fig. 5). Posterior mandibular barbels slightly longer than anterior pair, located behind and lateral to the anterior pair opposite the gular node (Fig. 5).

Body broadest anteriorly becoming increasingly compressed caudad. Caudal peduncle laterally compressed, twice as long as deep. Anus located posterior to base of pelvic fins and covered by fan of pelvics. Skin smooth.

Dorsal fin short, with straight posterior edge, basal third fleshy. Dorsal fin spine without serrations. Pectoral fins rounded. Anterior ray gently curved and spinous, serrated on postero-medial edge with 6 (juveniles) to 12 or 13 (usually 10 or 11 in adults) basally directed serrations. Pectoral fin formula I (N 54), 6 (N 4), 7 (N 50).

Pelvic fins rounded overlapping ventrally and short, not reaching anal fin. Pelvic fin formula I, 5 (N 54).

Anal fin rounded, fleshy over basal third, formula in Table 2.

Last anal ray divided or undivided to base. Caudal fin irregularly truncate, extending anteriorly on the dorsal and ventral edges of caudal peduncle. Principal caudal rays usually 8 + 9 (N 40), less frequently 9 + 8 (N 7); 9 + 9 (N 2); 7 + 9 (N 1); 7 + 8 (N 2); 8 + 8 (N 2) (holotype has 9 + 8). Procurrent rays as determined from cleared specimens: dorsal 16 (N 4), 17 (N 1), 18 (N 1); ventral 15 (N 1), 17 (N 4), 18 (N 1) (Table 4).

Adipose fin long and well developed, originating behind pelvic fin base, posteriorly detached.

Cephalic lateral line system unfragmented, course of canals shown in Fig. 9.

Lateral line straight, simple, extending mid-laterally from head to posterior end of caudal peduncle.

Alimentary canal (Fig. 6) short, with stomach expanded, bulbous and leading to the intestine on the left. Intestine crosses anteriorly to right before passing posteriad ventro-laterally and tucking behind the stomach. Thereafter it proceeds directly to the anus.

Gonads paired, ovaries simple, testes villiform.

Vertebral counts are recorded in Table 3.

TABLE 2.

*Distribution frequency of anal fin rays (A) G. barnardi N=54 (B) G. gilli N=20 (C) G. sclateri N=20*

		Branched rays											
		A				B				C			
		10	11	12	13	10	11	12	13	10	11	12	13
Unbranched Rays	iii		1	2	1								
	iv	6	16	7	1								
	v	4	9	3	1	6	6	1	1	1	3	3	1
	vi	1	2			3	1	1			3	8	

TABLE 3.

*Comparative distribution frequencies of vertebral counts of South African Gephyroglanis species**A. VERTEBRAE*

	N	41	42	43	44	45	46	47
<i>G. barnardi</i>	(32)		2	19	10	1		
<i>G. gilli</i>	(20)	1	9	10				
<i>G. sclateri</i>	(5)						1	4

*B. PRECAUDAL VERTEBRAE*

	N	11	12	13	14	15	16	17
<i>G. barnardi</i>	(32)		15	10	6	1		
<i>G. gilli</i>	(20)	3	7	9	1			
<i>G. sclateri</i>	(5)					1	3	1

*C. CAUDAL VERTEBRAE*

	N	28	29	30	31	32
<i>G. barnardi</i>	(32)		5	10	12	5
<i>G. gilli</i>	(20)	1	4	10	4	1
<i>G. sclateri</i>	(5)			2	2	1

*D. PREANAL FIN VERTEBRAE*

	N	19	20	21	22	23	24
<i>G. barnardi</i>	(32)		3	21	8		
<i>G. gilli</i>	(20)	2	8	8	2		
<i>G. sclateri</i>	(5)				2	1	2

TABLE 4.

*The number of caudal procurent rays in six cleared and stained paratypes of Gephyroglanis barnardi*

		Dorsal Procurent Rays		
		16	17	18
Ventral	15		1	
Procurent	16			
Rays	17	3		1
	18	1		

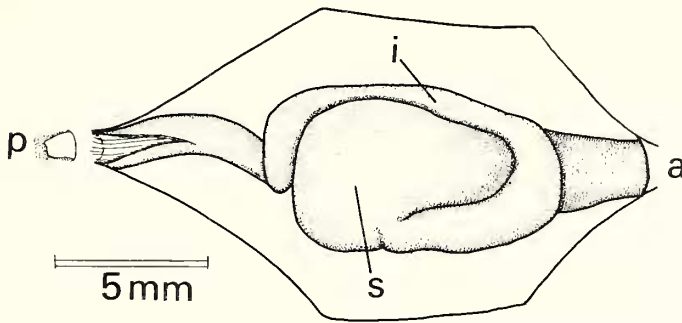


Fig. 6. Alimentary canal within the body cavity of *Gephyroglanis barnardi* sp. nov. (AM/P 1879 No. 2). Abbreviations: a—anterior; p—posterior; i—intestine; s—stomach.

#### *Comparison with Gephyroglanis gilli and G. sclateri*

*Gephyroglanis barnardi* may be distinguished from the sympatric *G. gilli* by the following characteristics: it is a smaller species (maximum recorded SL = 71 mm v. 127 mm of *G. gilli*); *G. barnardi* has dark brown spots and blotches, *G. gilli* is invariably without blotches or markings; *G. barnardi* has more slender curved dorsal and pectoral fin spines and these fins are shorter and more rounded than those of *G. gilli* which has well developed strong dorsal and pectoral spines and longer, straight, angulate fins (Fig. 3); the posterior edge of the caudal fin is more or less truncate in *G. barnardi*, in *G. gilli* this is emarginate (Figs 2 & 3); *G. barnardi* has fewer dorsal branched rays (six) than *G. gilli* (seven).

*G. barnardi* differs in several morphometric and osteological characters from *G. gilli*, particularly in having a smaller eye, shorter barbels, shallower head and body depth, shorter humeral process, nuchal plates separate from the supraoccipital process (in *G. gilli* the nuchal plates of the dorsal fin interlocks with the supraoccipital process), the caudal fin skeleton relatively consolidated (i.e. fused) compared with *G. gilli*, more vertebrae than *G. gilli* (Table 3).

*G. barnardi* is distinguished from *G. sclateri*, an Orange River endemic species, by its smaller maximum size, smaller eye, shorter snout, shallower body depth, longer caudal peduncle, shorter dorsal fin, number of branched dorsal fin rays, shorter humeral process and in the position of the posterior mandibular barbels. In addition the cephalic lateral line pores of *G. barnardi* are simple, those of *G. sclateri* are dendritic. The caudal fin of *G. barnardi* is truncate whereas that of *G. sclateri* is moderately forked. The caudal skeleton is more consolidated in *G. barnardi*. The supraoccipital process is joined with the first nuchal plate in *G. sclateri* but not in *G. barnardi*. There are fewer vertebrae in *G. barnardi* than in *G. sclateri* (Table 3).

#### *Distribution, habitat preferences and status*

*G. barnardi* is known only from the Noordhoeks and Thee rivers, two adjacent tributaries of the Olifants River system of the western Cape Province (Fig. 7). Both these tributaries are perennial mountain streams with gradients of approximately 1:30 (Noordhoeks) and 1:45 (Thee) over the accessible reaches where the species has been collected. The streams vary in width from three to six or seven metres wide during normal flow and are bedded with loose round rocks, pebbles and coarse clean sand. Vegetation is generally restricted to marginal



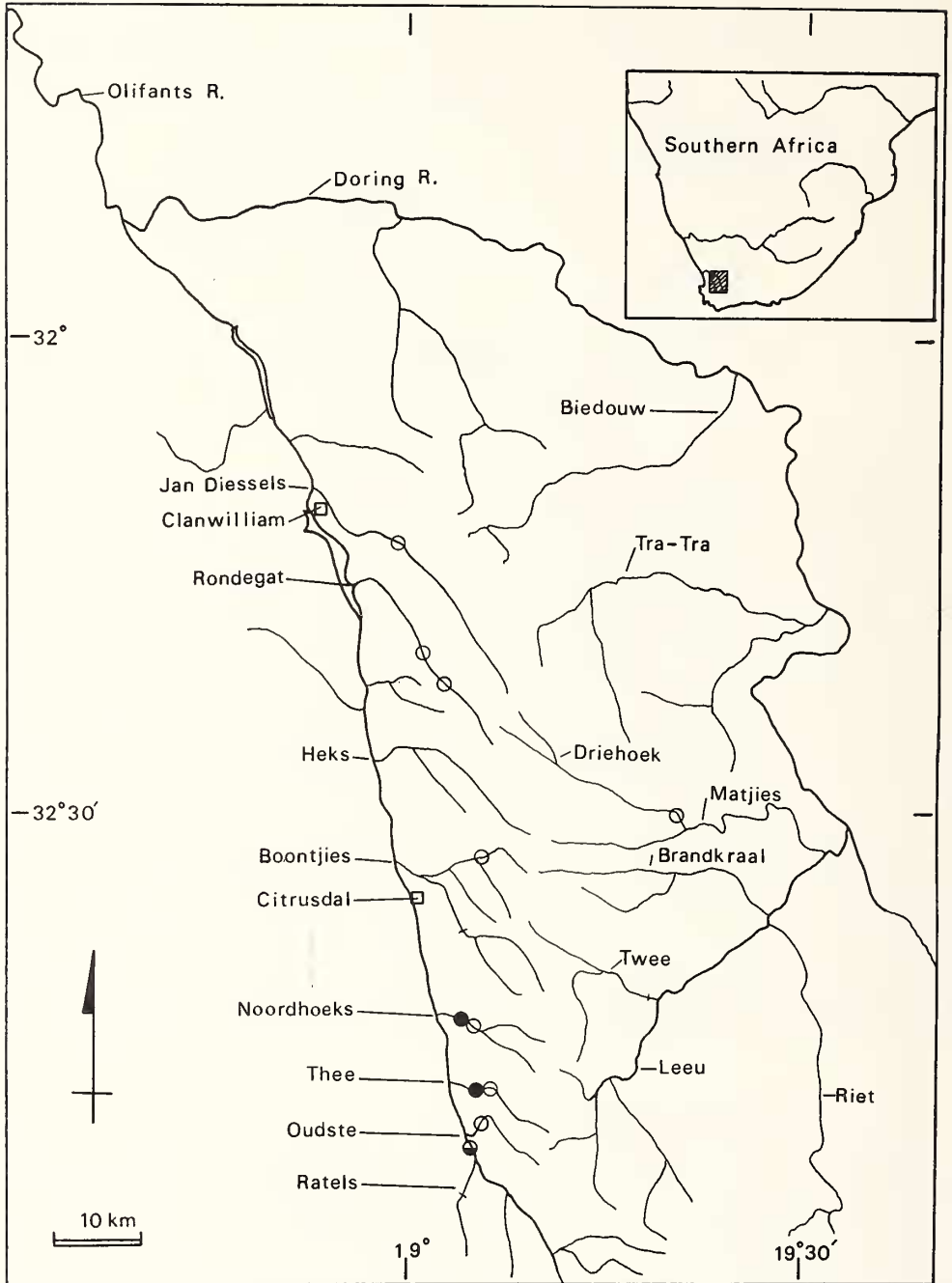


Fig. 7. The distribution of *Gephyroglanis barnardi* sp. nov. (closed circles) and *G. gilli* (open circles) in the Olifants River system, western Cape Province. Records as given in list of type material (*G. barnardi*) and in Appendix 1 (*G. gilli*). Half closed circle refers to SAM 19359/SAM 29232 from which either or both species may have been collected.

patches, frequently of Cyperaceae. Riffles and shallow runs alternate with deeper pools and the water is clear. *G. barnardi* is found together with *G. gilli* and the redfin minnow, *Barbus phlegethon*, in shallow (less than 1 m deep) flowing riffle stretches.

The confinement of *G. barnardi* to these two tributaries is surprising. Barnard may have collected this species from the mainstream at Keerom (cf SAM 29232) but it is possible that his specimens of *G. barnardi* may have been derived only from Noordhoeks as the evidence is equivocal. The habitat of the mainstream at Keerom is very similar to that in the Noordhoeks and Thee except that it is deeper, up to about two metres. Extensive surveys by the author and officials of the Department of Nature and Environmental Conservation throughout the Olifants system indicate that the species is probably restricted to these two streams and possibly to a few other adjacent streams in inaccessible localities. This restriction may be due in part to specific habitat preferences—which appear similar to those of *B. phlegethon*. This minnow species occurs almost exclusively in such shallow flowing, loose rock and pebble bottomed habitats of the clear water western Cedarberg tributaries of the mainstream Olifants River. The two strongest populations of *B. phlegethon* are those in the Noordhoeks and Thee rivers.

It is also likely that ecological changes in the Olifants River system resulting from human interference have acted to restrict *G. barnardi* and other indigenous species including *B. phlegethon* (Gaigher, 1978; Skelton, 1977). Agricultural practices and the introduction of exotic predatory fish species, notably smallmouth bass (*Micropterus dolomieu*) are undoubtedly the main factors involved (pers. obs.). From available records it would appear that *G. barnardi* is probably the rarest species in the Olifants and is therefore clearly an endangered species.

#### Etymology

The species is named for the late Dr Keppel Harcourt Barnard, former Director of the South African Museum. This name is particularly fitting because both of the other southern African *Gephyroglanis* species are named after Dr Barnard's predecessors at the South African Museum and furthermore Dr Barnard himself described *G. gilli* with which *G. barnardi* has been confused in the past. Finally it is clear from his writings that Dr Barnard had a particular interest in the fish fauna of the Clanwilliam Olifants River.

#### OSTEOLOGY

The following description of the osteology of *G. barnardi* is provided in order to form a base line study to which other *Gephyroglanis* species can be compared. The osteology of *G. sclateri* has been described by Petrick (1976) but that description is not generally available. Bone names are those in general usage (mainly after Weitzman, 1962) except in the following cases: Gosline (1975) for suspensorium; branchial and hyoid arches from Nelson (1969); epioccipital follows Paterson (1975); supracleithrum and posttemporal after Lundberg (1975); Weberian vertebrae follow the homology suggested by Chardon (1968). The term ethmoid is used here for the bone referred to as the mesethmoid or supraethmoid of various authors. Patterson (1975) has shown this bone to be derived from a supraethmoid and rostrodermethmoid.

#### Neurocranium (Figs 8a, b, c, d)

The *ethmoid* is a T-shaped bone, sutured postero-ventrally with the lateral ethmoids and the vomer and interdigitating postero-dorsally with the frontal and lateral ethmoids. The ethmoid is visible on the ventral side only as a narrow neck linking the broad premaxillae with the neurocranium.

The *premaxillae* are broad rectangular plates firmly attached to the ventral side of the T-bar of the ethmoid. Their ventral surface is almost entirely covered with slender, curved, sharp conical (macroscopically villiform) teeth.

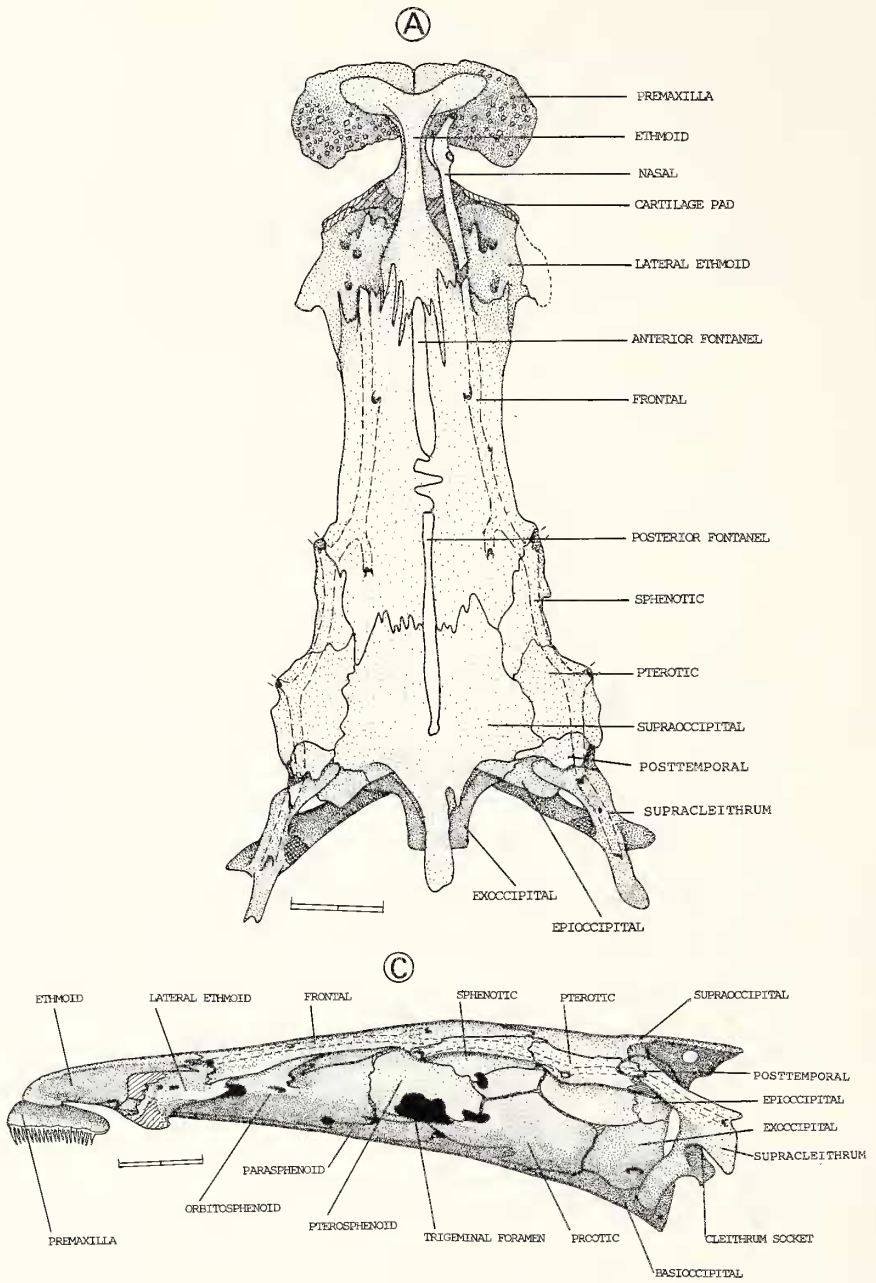
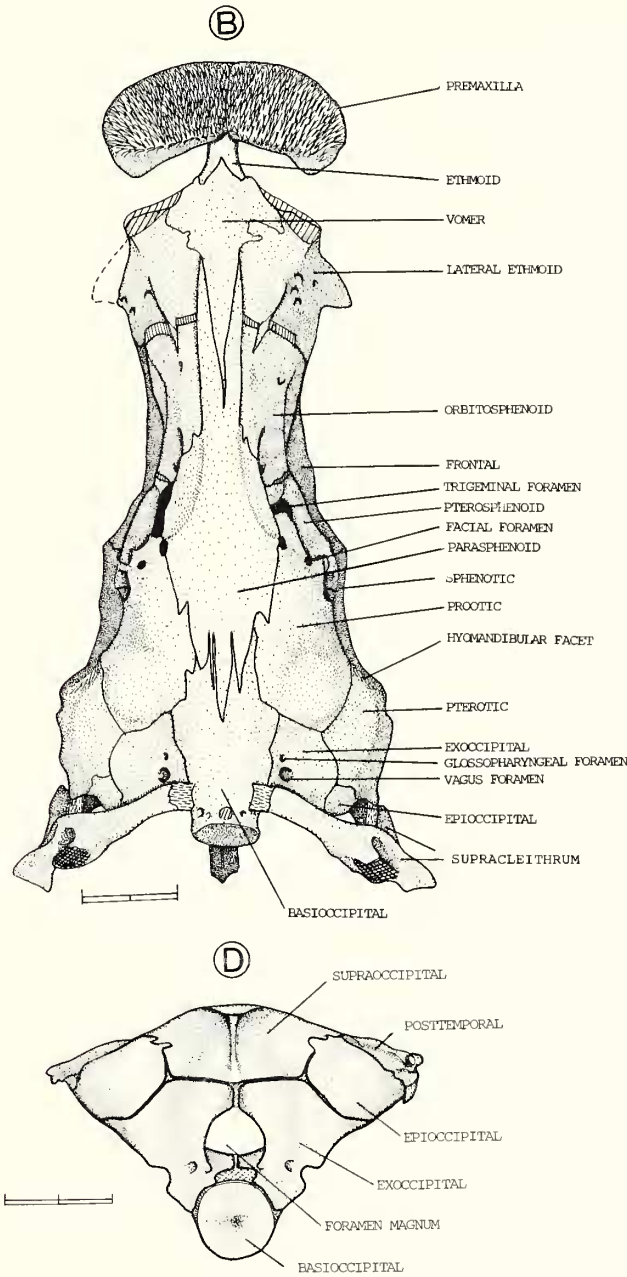


Fig. 8. Neurocranium of *Gephyroglanis barnardi* sp. nov. left nasal bone removed; B. ventral view

SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS



(W/P 893). Scale bar = 2 mm. A. dorsal view, C. left lateral view; D. posterior view.

The *lateral ethmoids* are prominent bones forming broad synchondral sutures posteriorly with the orbitosphenoids, dorsally with the frontals and anteriorly with the ethmoid. Antero-medially the lateral ethmoids are partially overlapped by thin lateral lamellae of the vomer. Their anterior and antero-ventral margin is encased in cartilage to form an articulation condyle for each palatine. The *vomer* is a blade-like bone articulating on the postero-ventral surface of the ethmoid and the antero-medial surface of each lateral ethmoid.

The canal-bearing *frontals* are elongated rectangular bones sutured anteriorly with the lateral ethmoids and supraethmoid and posteriorly with the supraoccipital and sphenotic bones. Each frontal counteroverlaps the other along a sinuous medial suture, except where the bones are separated to form elongated anterior and posterior fontanelles.

The *sphenotic*, *pteric*, *supratemporal* and *supraoccipital* bones form the posterior roofing bones of the neurocranium. The *sphenotics* lie postero-laterally to the frontals, anteriorly to the pterotics and usually latero-anteriorly to the supraoccipitals. The neurocranium broadens at the level of the *pteric* and these bones form the postero-lateral portion of the braincase. Each pterotic provides passage for a portion of the posttemporal canal of the cephalic lateral line system, as well as internally for the horizontal semicircular canal. A shallow hyomandibular facet is formed jointly by the pterotic and sphenotic bones. The large pan-shaped *supraoccipital* extends over the postero-medial portion of the neurocranium. Anteriorly a deep medial notch in the supraoccipital forms the posterior part of the posterior fontanel. Posteriorly a slender medial process extends towards but does not reach the first nuchal plate of the dorsal fin skeleton.

The *parasphenoid* forms a narrow strut anteriorly where it is partially overlapped by the vomer. On the dorsal side it is sutured in turn to the lateral ethmoids, orbitosphenoids and prootics. Posteriorly the parasphenoid interdigitates with the basioccipital.

Anteriorly the *orbitosphenoid* forms a dual synchondral suture divided by a groove and foramen with the lateral ethmoids. Dorsally each orbitosphenoid meets the respective frontal along a simple suture. Posteriorly there are synchondral sutures with the pterosphenoids. The orbitosphenoids are closely applied to the parasphenoid without an inter-orbital septum being formed.

The *pterosphenoids* meet the frontals on the antero-dorsal side, the sphenotics postero-dorsally and, over a short length, the parasphenoids ventrally. Anteriorly the pterosphenoids are synchondrally united to the orbitosphenoids. Posteriorly and postero-ventrally an irregular junction with the prootics allows for the formation of the large trigeminal foramen. A smaller facial foramen also provides a break in the suture between each pterosphenoid and prootic.

The large *prootics* form hemispherical bulges (*bullae acusticae lagenaris*) on the ventral surface of the neurocranium. Anteriorly the prootics suture with the pterosphenoids, dorsally with the sphenotics and the pterotics, ventrally with the parasphenoid, postero-ventrally with the basioccipital and posteriorly with the exoccipitals.

The *basioccipital* forms an interdigitating suture anteriorly with the parasphenoid, and is synchondrally sutured to either prootic antero-laterally and the exoccipitals laterally. The ventral limb of the posttemporal is attached to the postero-lateral sides of the basioccipital by means of a ligament. The basioccipital houses the major portion of each sagitta and, in part, each asteriscus.

The *exoccipitals* suture with the basioccipitals laterally and dorsally. They include both the glossopharyngeal (IX) and vagus (X) foramina. The foramen magnum is bounded by the exoccipitals (latero-dorsally) with a small portion provided by the basioccipitals on the ventral side. (Lamellae of the exoccipitals meet in the midline to form the posterior floor of the brain case.)

The *epioccipitals* are sutured to the exoccipitals, supraoccipitals, and pterotics and are overlain by the supratemporals and, in part, the posttemporals. The dorsal section of the posterior



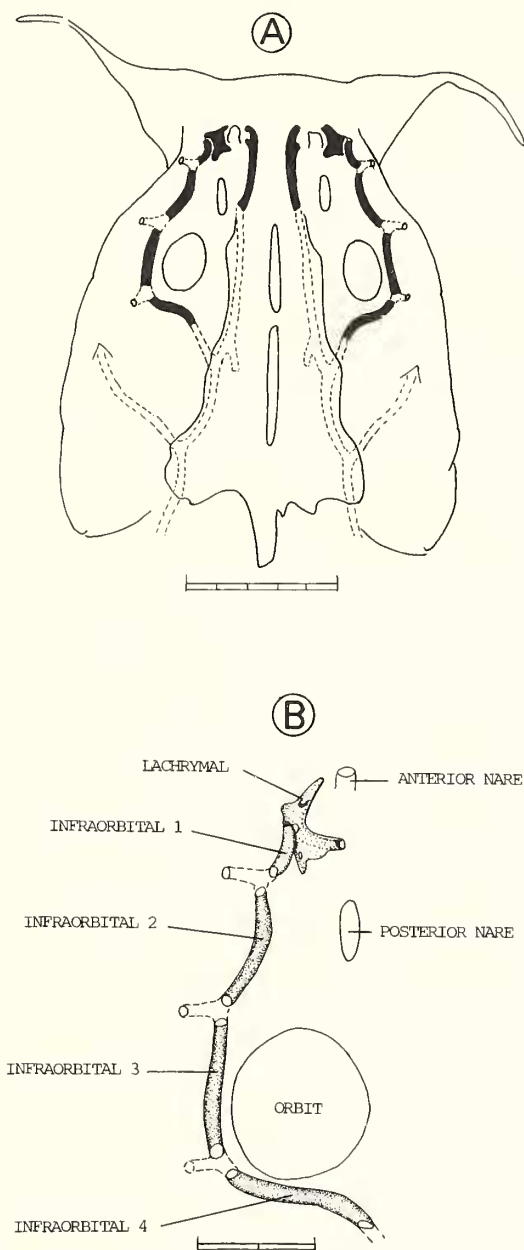


Fig. 9. A. Diagram of dorsal view of head of *Gephyroglanis barnardi* sp. nov. to illustrate *in situ* position of nasals, infraorbital bones, lachrymal and the course of the cephalic lateral line system. Note preoperculomandibular lateral line canal extends to dentary (cf. Fig. 12). B. Infraorbital bones and lachrymal of *Gephyroglanis barnardi*.

vertical semi-circular canal passes obliquely through each epioccipital providing passage from the exoccipitals, which continues dorsally into the supraoccipital.

The *posttemporals* are small plates overlying the epioccipitals and articulating with the extremity of the dorsal limb of the supracleithrum. A short canal through the posttemporal links the supracleithral portion with the pterotic portion of the cephalic lateral line canal.

The *supracleithra* are large V-shaped bones each with a dorsal limb articulating in a groove between the epioccipital and the supratemporal. A channel through this limb provides passage for the cephalic lateralis lateral line canal. The ventral limb is attached from its medial extremity to the side of the basioccipital. At the lateral base of the ventral limb a large round groove or cavity, closed posteriorly by tough connective tissue, accommodates the dorsal extremity of the cleithrum.

*Infraorbitals and nasal bones (Figs 8a, 9a and b)*

The *nasal bones* are elongate tubular units lying lateral to the stem of the ethmoid. They have a short branch leading to an opening about midway along their length and their rostral end turns laterad. The *infraorbital* series are tubular bones comprising a triradiate lachrymal, a short first infraorbital and three longer, gently curved second, third and fourth infraorbitals. The lateral line canal branches to a pore at each interconnection.

*Suspensorium, palatine-maxilla and preopercular (Figs 10a and b, 11, 12).*

The *hyomandibular*, *preopercular*, *quadrate* and *metapterygoid* are welded together to form a large plate-like unit. The *hyomandibular* articulates in a facet formed by the sphenotic and pterotic and also has a posterior spherical facet with which the opercle articulates. Anteriorly it sutures by means of an interdigitation with the metapterygoid. Ventrally it is sutured with the preopercle. There is an arcuate symplectic-cartilage between the hyomandibular and the quadrate on the antero-ventral edge of the former bone. A canal through the hyomandibular provides passage for the facial nerve which passes medio-dorsally—latero-ventrally and emerges laterally from a notch on the preopercular. There is a narrow lateral ledge on the hyomandibular providing attachment for the levator arcus palatini muscle.

The *preopercle* is firmly sutured dorsally to the hyomandibular and the quadrate. Antero-ventrally a ledge of the quadrate lies lateral to the preopercle, on the posterior side a flange of the preopercle lies lateral to the quadrate. The flange also covers portions of the symplectic cartilage and the hyomandibular. The lateral line canal passes through the length of the preopercle with two intermediate branches to pores terminating on the ventral edge of the bone.

The *quadrate* is stout and squarish, forming an arcuate synchondral junction with the hyomandibular dorsally, an interdigitating suture with the metapterygoid anteriorly and is sutured posteriorly with the preopercle.

The *metapterygoid* is the smallest bone in the unit and forms interdigitating sutures ventrally and posteriorly with the quadrate and hyomandibular respectively. The symplectic cartilage joins the bone postero-ventrally.

The *mesopterygoid*, *ectopterygoid* and *palatine* (Fig. 11) are loosely connected to the metapterygoid by means of ligaments. The *mesopterygoid* is flat and square-shaped with a prominent projection from the postero-medial corner. This bone is closely sutured with the smaller flat *ectopterygoid* to form a single unit which is closely attached (ligamentously) to the posterior portion of the palatine. The *palatine* is rod-like, the anterior portion thick and stout and the posterior section narrow and cylindrical. Midway along its length on the dorsal side there is a prominent saddle-like articulation facet for the lateral ethmoid. A cartilage pad extends from each extremity, with the large anterior pad articulating directly with the maxilla.

SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS

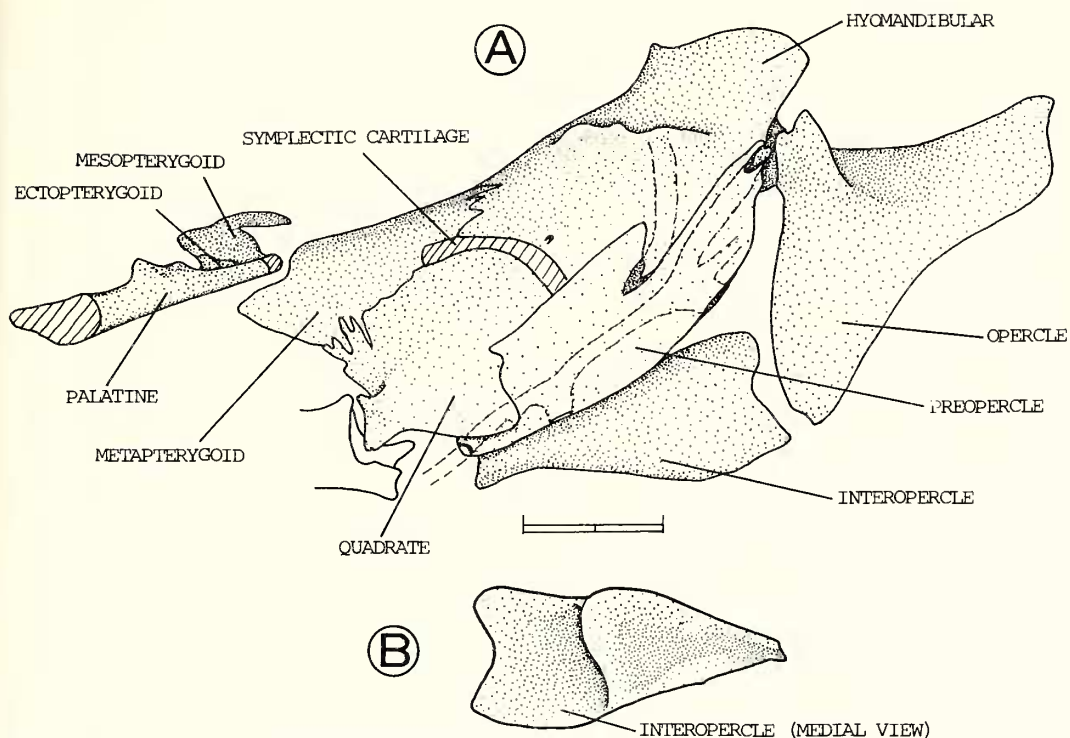


Fig. 10. A. Lateral view of left suspensorium of *Gephyroglanis barnardi* sp. nov. B. Medial view of interopercle. Scale bar = 2 mm.

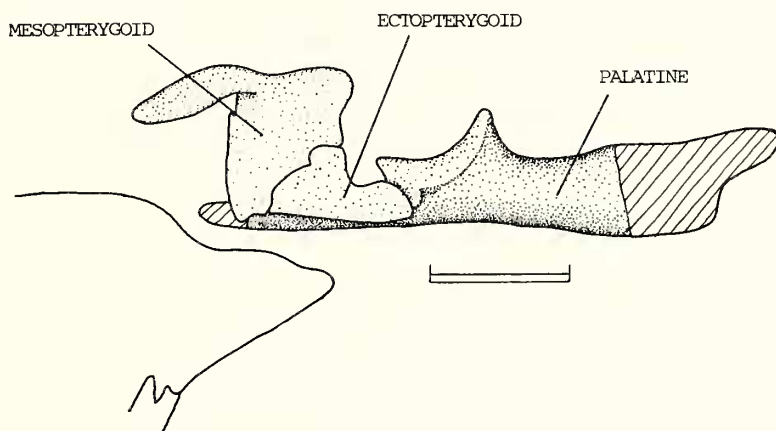


Fig. 11. Medial view of mesopterygoid, ectopterygoid and palatine of *Gephyroglanis barnardi* sp. nov. Scale bar = 1 mm.

Fig. 12. Left maxilla of *Gephyroglanis barnardi* sp. nov., ventral view. Scale bar = 1 mm.

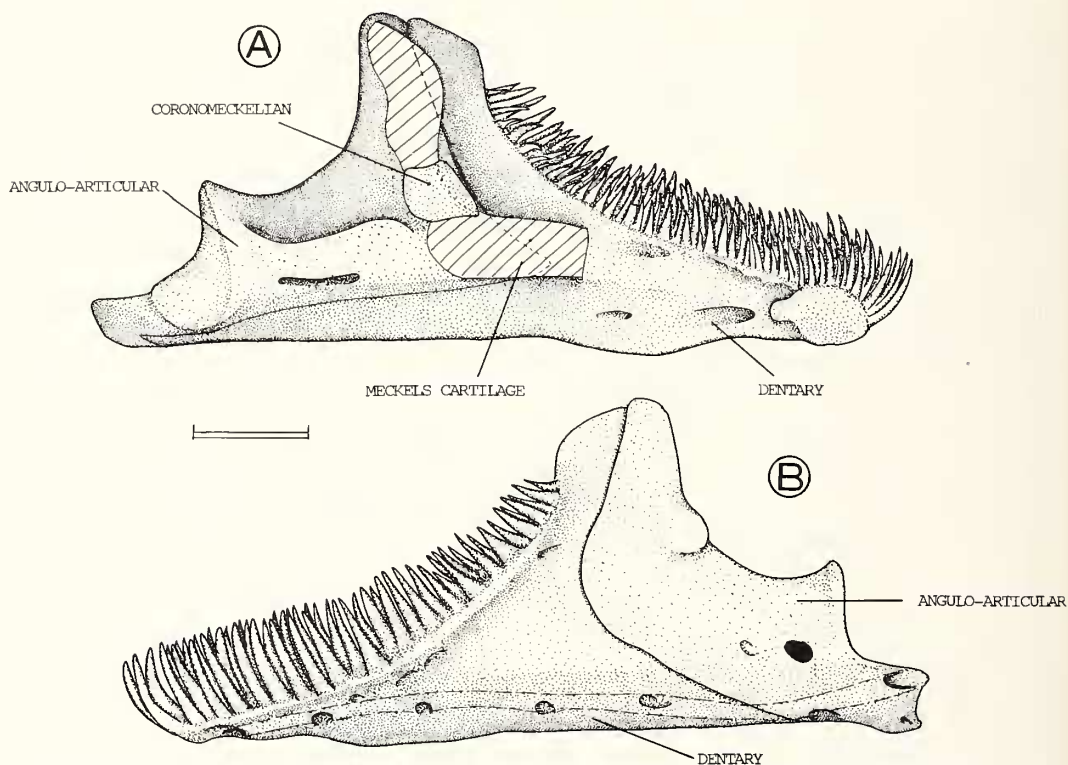
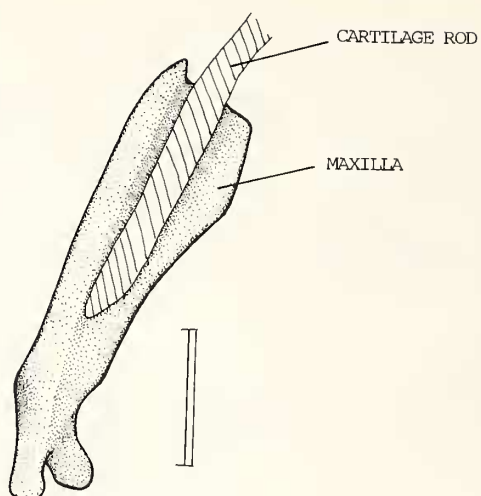


Fig. 13. Left lower jaw of *Gephyroglanis barnardi* sp. nov. A. medial view; B. lateral view. Scale bar = 1 mm.

The *maxilla* (Fig. 12) is a stout compressed rod articulating proximally with the palatine cartilage. A constriction precedes the dual ridged articulation head. A cartilage rod supporting the maxillary barbel extends from a groove on the antero-ventral side.

*Opercular series* (Fig. 10a)

As in all catfish there are no subopercles. The opercle is a slender triangular bone articulating, at the apex, with the hyomandibular by means of a ball and socket articulation. The paddle-shaped *interopercle* is hollow medially with a transverse division forming a facet for the abutment of the postero-lateral edge of the posterohyal. In front of the facet, an elongated groove accommodates the large ligament joining the posterohyal to the angulo-articular.

*Lower jaw* (Fig. 13)

This consists of three bones, the *angulo-articular*, the *dentary* and the *coronomecklian* as well as Meckel's cartilage. The triangular *dentary* is gently curved and bears slender, curved teeth in a broad band from two to seven or eight teeth wide. The mandibular lateral line canal passes along the ventral side of the dentary and has four intermediate pores. A hollow on the postero-medial aspect of the dentary accommodates the angulo-articular and Meckel's cartilage.

Posteriorly the *angulo-articular* is stout and large supporting a large saddle-like articulation facet. Anteriorly the bone is compressed and projects dorsally to form the posterior section of the ascending process of the jaw. A rounded projection (boss) on the postero-lateral edge of the dorsal limb provides an attachment point for the adductor mandibulae muscle. There is a large medio-dorsal excavation in front of the articulation facet. The lateral line canal passes obliquely through the postero-lateral part of the angulo-articular with a single intermediate pore. Meckel's cartilage extends anteriorly to meet the dentary and also forms a dorsal branch which lies in a medial groove on the dorsal limb of the angulo-articular.

The *coronomeckelian* lies medial to the dentary and angulo-articular and wraps around the dorsal limb of Meckel's cartilage.

*Hyoid arch* (Figs 14 and 15)

A small irregularly spherical *interhyal* is present above the triangular posterohyal.

The postero-lateral extremities of the *posterohyal* forms a rounded condyle which articulates in ball and socket fashion within the facet on the interopercle (similar to that described for *G. gilli* and *G. sclateri* by Petrick, 1973). A large ligament attaches to the anterior surface of this condyle and joins the posterior edge of the angulo-articular.

Posteriorly the *anterohyal* is deep and laterally compressed and sutures to the posterohyal. Its anterior end is triangular in transverse section where it is sutured with the relatively large ventrohyal and the smaller dorsohyal.

The *ventrohyal* has a stout triangular lateral portion which sutures to the anterohyal. Medially the ventrohyal is depressed and forms a condyle which articulates both the urohyal and also its opposite fellow. Posteriorly the ventrohyal sutures with the dorsohyal. The smaller *dorsohyal* is a depressed rectangular bone joined laterally with the anterohyal and anteriorly with the ventrohyal (absent from the illustrated individual).

There are usually six *branchiostegal* rays on each arch, five articulating with the anterohyal and one with the posterohyal. The first three or four curved acinaciform rays increase progressively in size posteriorly. Each has a Y-shaped head which articulates on the ventral edge of the anterohyal. The fifth and sixth branchiostegals are spathiform, the fifth articulates on the postero-ventral angle of the anterohyal and the sixth on the antero-ventral angle of the posterohyal.



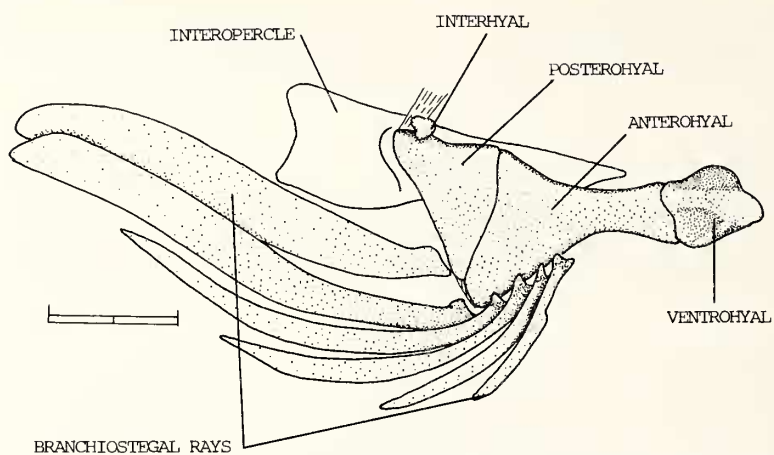


Fig. 14. Medial view of left hyoid arch of *Gephyroglanis barnardi* sp. nov. (dorsohyal absent). Scale bar = 2 mm.

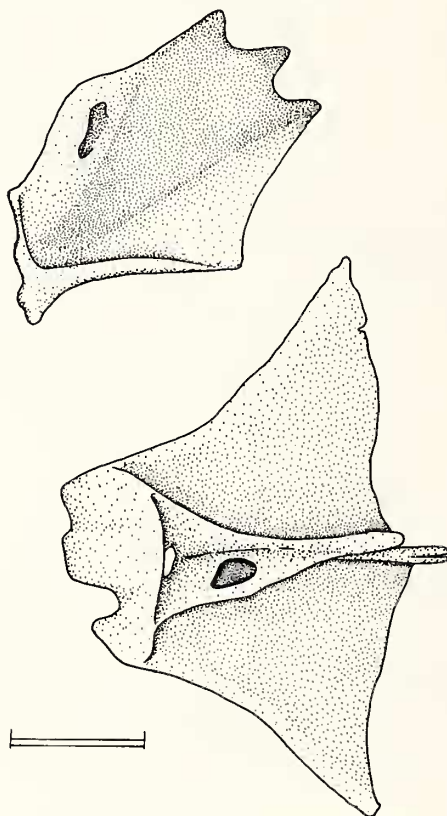


Fig. 15. Lateral view (above) and dorsal view (below) of the urohyal of *Gephyroglanis barnardi* sp. nov. Scale bar = 1 mm.

The *urohyal* (Fig. 15) is a short triangular bone truncated posteriorly with a median dorsal flange. The flange divides anteriorly on the dorsal side to form an articulation bracket for the leading basihyal cartilage. The bracket is flanked anteriorly on each side by an attachment surface for a ligament connecting to the ventral side of either ventrohyal. A median canal passes ventrad behind the attachment surface.

*Branchial Skeleton (Figs 16a, b, c)*

As the interpretation and homology of the siluroid branchial skeleton does not appear to be satisfactorily determined, nomenclature and interpretation of Nelson (1969) will be followed.

There are three *infrapharyngobranchials* on each side. The first is a small slender sliver of bone, sometimes absent, lying anterior to the first epibranchial. The second is entirely cartilagenous and lies at the head of the first epibranchial between the latter and the third infrapharyngobranchial. The third infrapharyngobranchial is elongate and club-like with the broader end posteriorly abutting the fourth upper toothplate.

There are two *upper toothplates*—here termed the fourth and fifth after Nelson (1969)—the fourth is a short club-like bone, edentulous, suspending on its ventral side the large oval fifth upper toothplate. The ventral side of the fifth toothplate is entirely toothed with long slender caniniform teeth (Fig. 16c).

There are five *epibranchials*. The first epibranchial is the largest and has a rod-like medial section extending laterally into a longer dorsoventrally compressed portion. There are three or four long gill rakers along the outer anterior edge. There is a short cartilage pad at each end of the bone. The second epibranchial is similar though slightly smaller than the first. The medial extremities of these two epibranchials lie close together and abut the cartilagenous second infrapharyngobranchial. The third epibranchial is a shorter more slender bone with a prominent dorsal process on the mid-posterior side. The epibranchial joins between the third infrapharyngobranchial and the fourth upper toothplate. The fourth epibranchial is shorter than the preceding three but is less rod-like and forms a low triangular posterior flange. The fifth epibranchial is represented by a small but distinct cartilage rod extending off the posterior edge of the fourth ceratobranchial.

There are five *ceratobranchials* the anterior three of which are relatively simple arched struts, grooved to form a trough on the ventral side and having short cartilagenous extremities. Each successive bone is progressively shorter than the previous one. The fourth ceratobranchial differs in that the medial extremity turns anterad and forms an enlarged cartilage pad. The fifth ceratobranchials are expanded posteriorly to form a dentigerous surface. Their extremities consist of short cartilage pads. The teeth on the fifth ceratobranchials are slender, curved and caniniform.

There are three pairs of *hypobranchials* of which the anterior two are ossified and the third entirely cartilagenous. The bony hypobranchials are dorso-ventrally compressed, broader laterally and more slender medially. The extremities are in all cases cartilagenous. The third hypobranchials are stout cartilage bars against which on the posterior edge the third and fourth ceratobranchials as well as the cartilagenous posterior basibranchial copula articulate.

The *basibranchials* are represented by an anterior series of closely connected cartilage and bony units (representing basibranchials 1–3) and an independent cartilage copula posteriorly. The anterior series consists of a cartilage pad backed with a bony section, a second cartilage pad and bone which passes ventral to the third hypobranchial cartilages and itself ends in the form of a small cartilage. The posterior hypobranchial forms a large rectangular cartilage pad articulating anteriorly with the third hypobranchials, posteriorly with the fifth ceratobranchials and laterally with the medial cartilages of the fourth ceratobranchials.

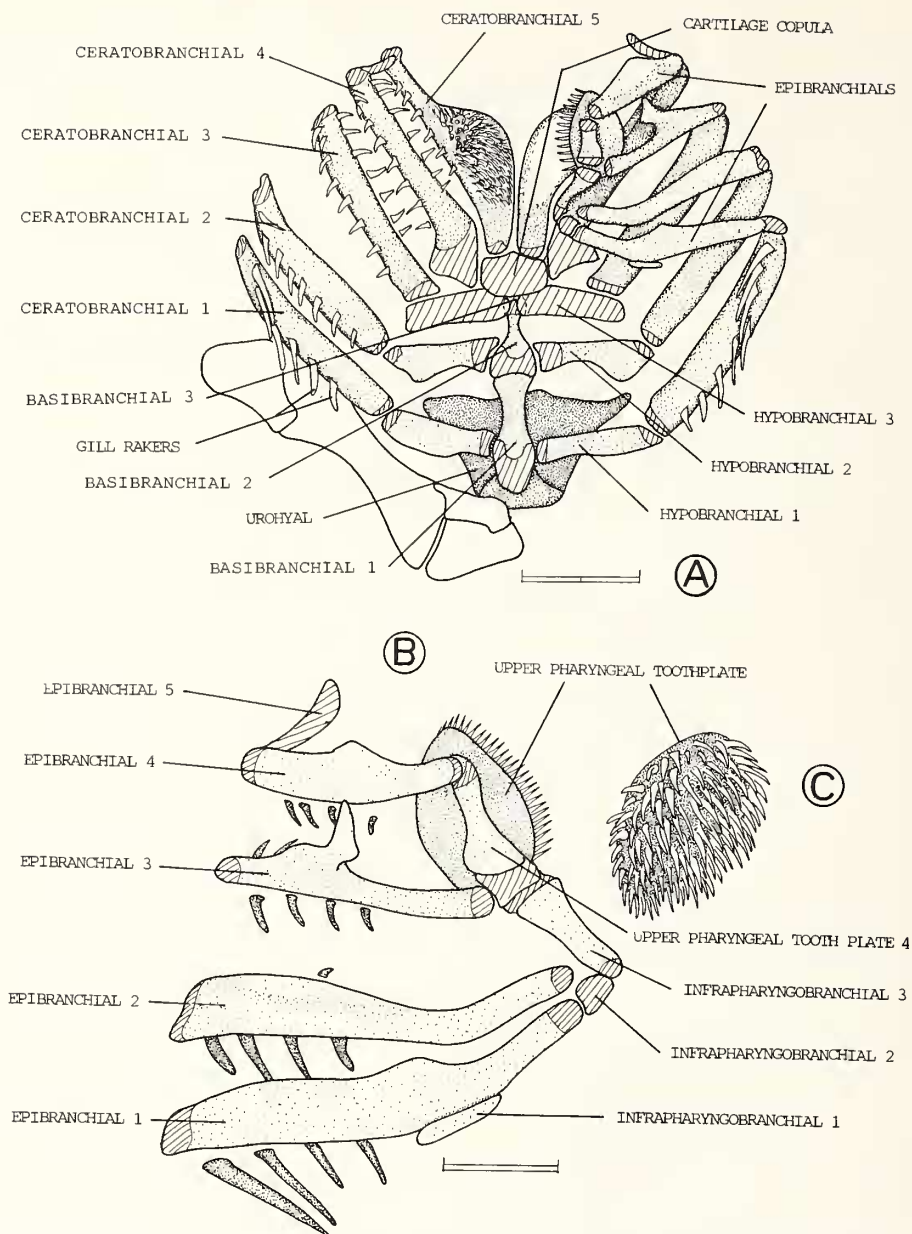


Fig. 16. A. Dorsal view of the branchial skeleton of *Gephyroglanis barnardi* sp. nov. with right epibranchials, infra-pharyngobranchials and upper tooth plates removed. Left gill rakers only depicted on 1st cerato-branchial. Scale bar = 2 mm.

B. Dorsal view of right epibranchials, infra-pharyngobranchials and upper tooth plates. Scale bar = 1 mm.

C. Ventral view of right upper tooth plate, same scale as B.

There are six to nine simple *gill rakers* along the anterior edges of all ceratobranchials and three to four similar rakers along the anterior edges of the epibranchials (except the fifth). There are no gill rakers along the posterior edges of the first, second and fifth ceratobranchials or the first, and fifth epibranchials. A single small gill raker is irregularly present on the posterior edge of the second epibranchial.

*Pectoral girdle (Figs 17a, b, c)*

The pectoral girdle on each side consists of the supracleithrum, cleithrum, mesocoracoid, coracoid and radials. The supracleithrum has already been described (see above). The *cleithrum* is the largest single element in the girdle and unites medially in a symphysis with its opposite member. The dorsal limb of the cleithrum terminates in a stout peg which articulates within the socket of the supracleithrum. There is a short and relatively broad posterior humeral process at the base of the dorsal limb. The ventral limb is directed medially and forms a broad flat plate. The cleithrum folds over latero-ventrally to form a thick lip which partly encloses a deep ventral groove in which the base of the pectoral spine articulates.

The *coracoid* is a large complex bone sutured postero-medially to the cleithrum and articulating by means of a well developed interdigitating junction with its opposite member. On the ventral side of the girdle the coracoid forms a bridge over the cleithral groove and sutures on the thick overfolded lip. An articulation condyle for the pectoral spine is formed at the posterior base of the bridge. On the antero-ventral side of the coracoid forms a narrow ridge or flange which decreases in altitude to disappear medially.

The *mesocoracoid* is represented by a thin strut which runs from the posterior end of the ventral coracoid ridge to the posterior edge of the coracoid. A notch on the posterior side of the base of the strut forms an articulation facet for the median radial. A foramen on the coracoid above the base of the mesocoracoid allows for the movement of the head of the pectoral spine.

There are three proximal *radials* and two smaller distal ones. The first proximal radial is a large trapezoidal cartilage located posterior to the base of the pectoral spine. This assists in the articulation of the pectoral spine as well as of the following two rays. The second and third proximal radials are rod-like bones connecting the posterior four rays with the coracoid. The two small secondary or distal cartilage radials occur between the first and second proximal radials and the fin rays.

*Weberian apparatus (Figs 18a, b, c, d)*

The complexities of the siluroid Weberian apparatus have been described by several authors, most notably by Chardon (1968). The fusions and modifications are such that the individual components are not readily recognizable and the present description aims solely to provide a comparative base for *G. barnardi*.

The first vertebra is represented by the centrum only, and this is compressed to a thin plate. The second to fourth vertebrae are indistinguishably fused and joined by an elaborately interdigitating suture to the fifth vertebra to form a single complex. A complex shield is developed above the centra of these vertebrae and has on each side a large bony strut (the anterior branch of the parapophyses of the fourth vertebra) which extends antero-laterally and is firmly bound to the ventral limb of the posttemporal. The posterior branch of the fourth parapophyses form slender projections from the shield. On the dorsal side a strong V-shaped strut (fourth neural spine) emerges, forms the neural arch and sutures with the third proximal pterygiophore of the dorsal fin. On the ventral side of the complex there is a well developed aortal groove which extends posteriad over the fifth and subsequent precaudal vertebrae.

The parapophyses of the fifth vertebra form prominent projections dorso-laterally. The enlarged proximal pterygiophore of the second dorsal spine lodges within a pit on the dorsal side of the fifth vertebra. The sixth vertebra is the first to carry pleural ribs. Like the fifth



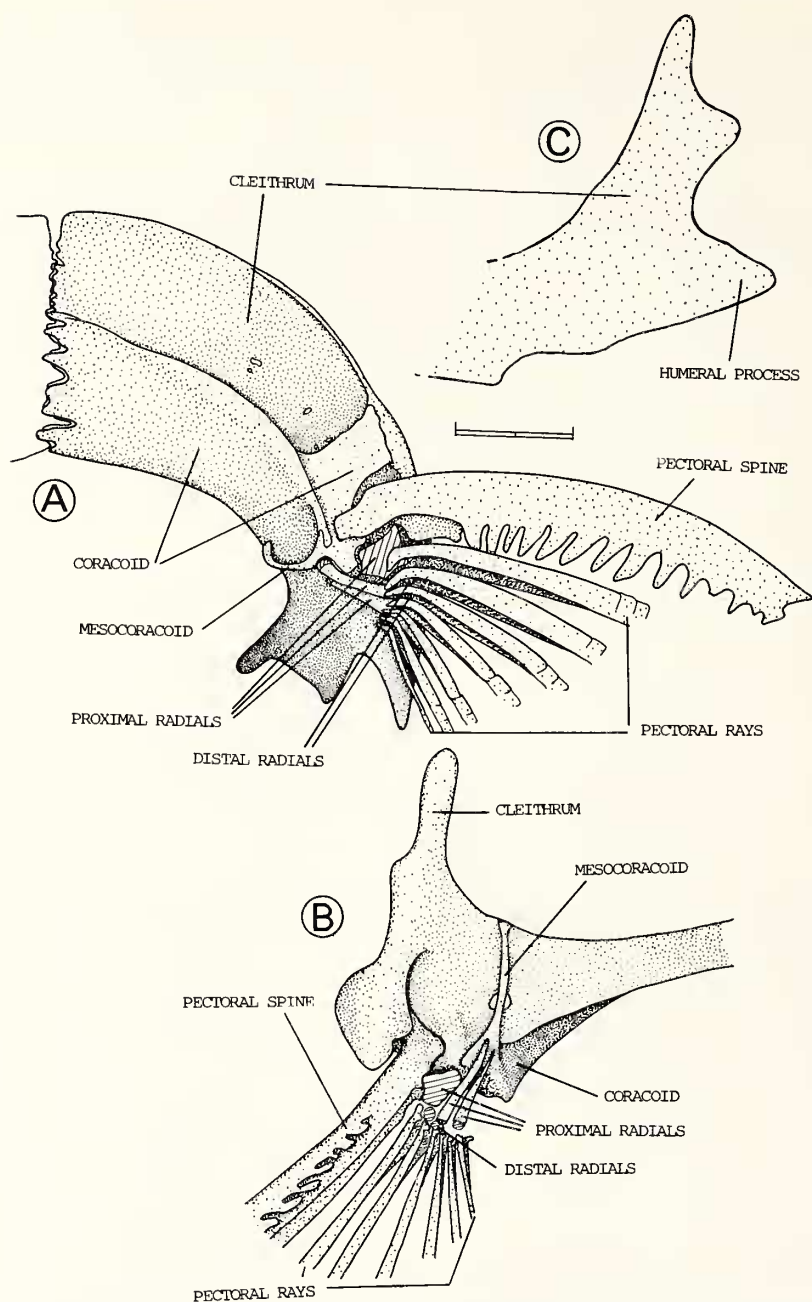


Fig. 17. A. Ventral view and B. posterior view of left pectoral girdle of *Gephyroglanis barnardi* sp. nov. C. Lateral profile of cleithrum of *Gephyroglanis barnardi* sp. nov. Scale bar = 2 mm.



# SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS

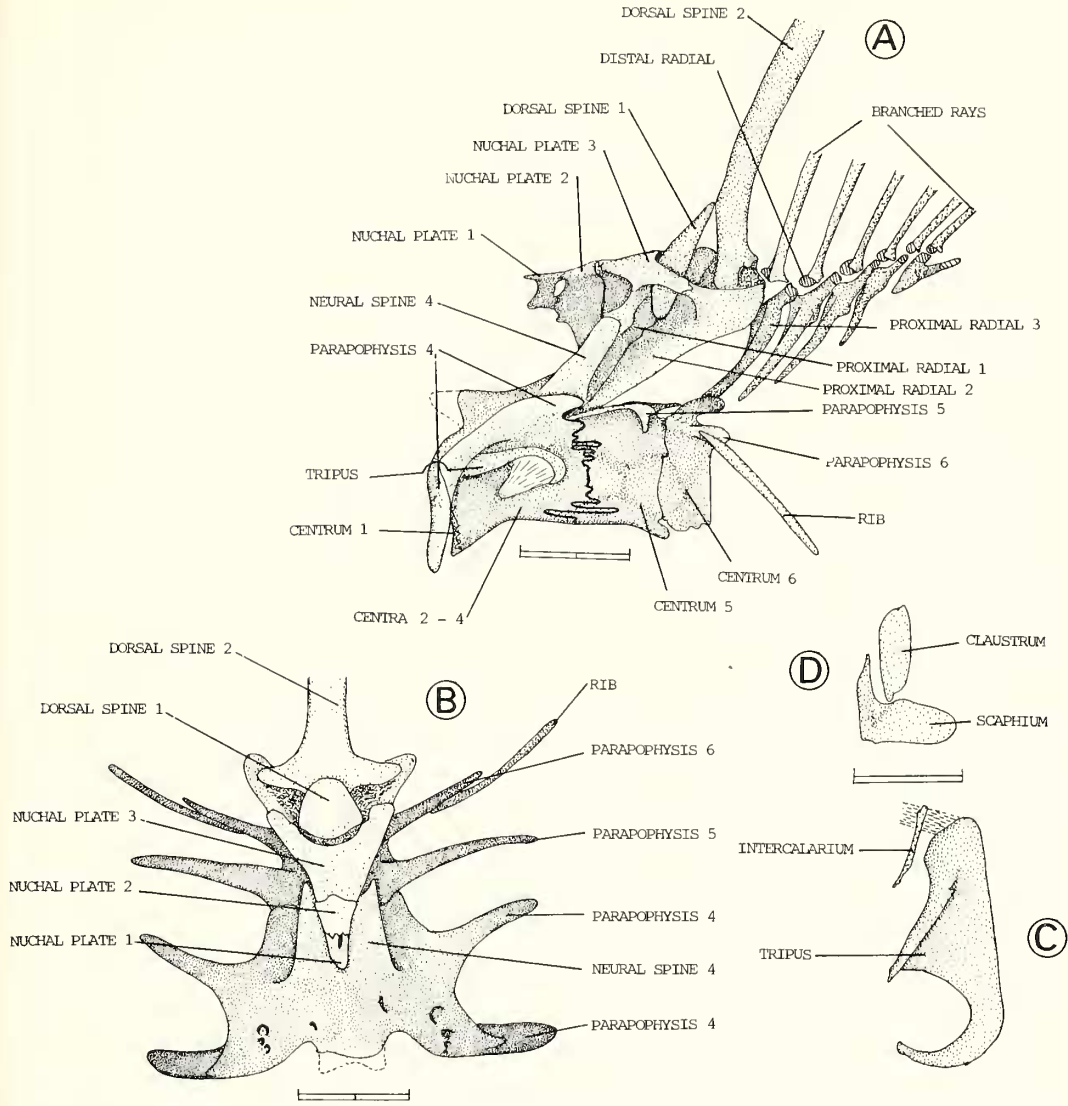


Fig. 18. A. Lateral view and B. dorsal view of Weberian vertebrae and dorsal fin skeleton of *Gephyroglanis barnardi* sp. nov. Scale bar = 2 mm. C. Dorsal view of right tripus and intercalarium and D. lateral view of right scaphium and claustrum of *Gephyroglanis barnardi* sp. nov. C & D Scale bar = 1 mm.

vertebra the parapophyses of the sixth are well developed as dorso-lateral projections. The pleural ribs are connected to the antero-ventral edge of the projections. The neural arches of this vertebra are short and directed posteriad, uniting behind the fifth proximal pterygiophore. The fifth pterygiophore is thus held within a receptacle bounded anteriorly by the neural arches of the fifth vertebra and laterally and posteriorly by the neural arches of the sixth vertebra.

The *tripus* is attached to a bony flange beneath the dorsal shield of the anterior vertebral complex. The tripus itself is elongate, and thin with a flat postero-medial projection and a tapering lunate transformator process. Anteriorly the tripus is linked to the slender rod-like *intercalarium*.

The *scaphium* lodged within a notch in the exoccipital is in turn connected by means of a short ligament to the intercalarium. It is an L-shaped bone with the horizontal limb broader and larger than the vertical limb. The simple leaf-like *claustrum* lies within the angle of the scaphium.

#### *Precaudal vertebrae*

The neural arches of the seventh and eighth vertebrae form a broad groove which accommodates the dorsal fin pterygiophores. The neural spines of the ninth and subsequent vertebrae become progressively longer and reach a maximum at about the fifteenth or sixteenth vertebra. The parapophyses of the precaudal vertebrae likewise progressively decrease in size. The development of a closed haemal arch at about the twelfth vertebra precedes the disappearance of distinct parapophyses and the formation of a haemal spine at about the fifteenth vertebra. In consequence there are several vertebrae with a closed haemal arch, parapophyses and attached pleural ribs.

#### *Caudal vertebrae (see Fig. 19)*

The caudal vertebrae are, apart from the first few with non-united parapophyses and short haemal spines, reasonably uniform in character. They all have well developed neural and haemal spines, pre- and post-neurapophyses and the majority have pre- and post-haemapophyses. Three or four preural vertebrae lack post-haemapophyses and their pre- and post-neurapophyses merge with the neural arch.

#### *Caudal skeleton (Fig. 19)*

The caudal skeleton is characterized by the near complete fusion of the hypurals into two hypural plates. The compound ural centrum ( $Pu_1 + U_1$ ) is fused with the parhypural and hypurals 1 and 2 as well as the uroneurals 1 and 2 to form a single unit. Weak suture lines between the hypurals 1 and 2 and the parhypural are still evident. Hypurals 3 to 6 are also fused into a single plate although here only a single suture line is still evident. A well developed hypurapophysis on the base of the parhypural is joined to a secondary hypurapophysis on the base of hypural 1 (i.e. type A hypurapophysis of Lundberg and Baskin, 1969).

A small cartilagenous third uroneural is present between the first dorsal principal caudal ray and the last dorsal procurent ray. There is a single epural. Procurent rays vary between 15 and 18 (Table 4) with three of the six cleared specimens having 16 dorsal and 17 ventral procurent rays.

#### *Dorsal fin skeleton (Figs 18a and b, 20)*

The first nuchal plate is small and triangular and is fused to a median plate or flange derived, according to Alexander (1966), from a supraneural bone. This compound unit is sutured posteriorly to a second slightly larger but essentially similar nuchal plate. This in turn is fused to a third larger Y-shaped nuchal plate and the proximal radial of the first pterygiophore. This radial has bilateral transverse flanges which suture with the dorsal V-shaped projection of

# SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS

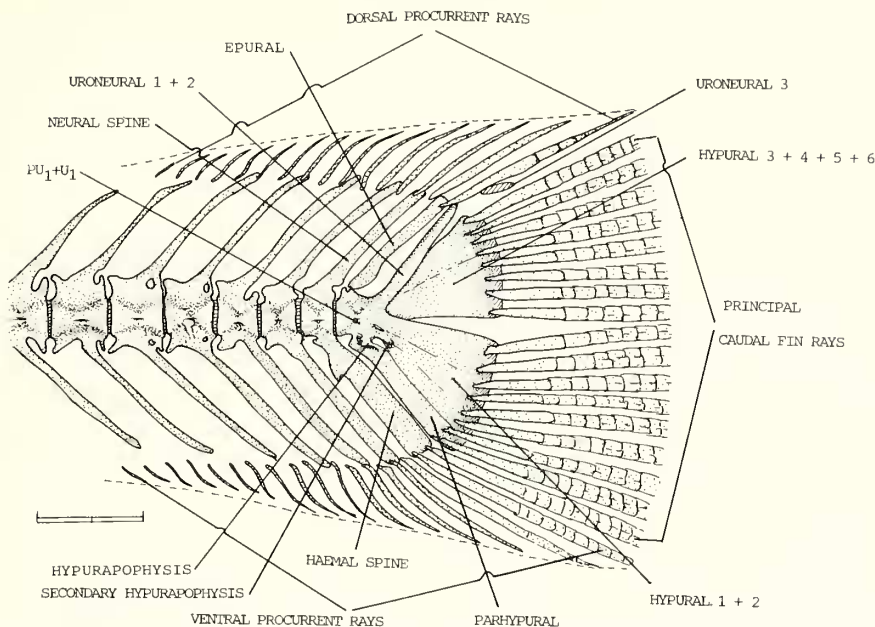


Fig. 19. Lateral view of caudal fin skeleton of *Gephyroglanis barnardi* sp. nov. Scale bar = 2 mm.

the fourth neural spine. The postero-dorsal portion of the first radial is thickened and knob-like and is straddled anteriorly by the first spine. A large proximal radial of the second pterygiophore lodges within a pit on the dorsal side of the fifth vertebra and sutures anteriorly with the first proximal radial. The dorsal surface is roughened and expanded to form a friction pad for the base of the second dorsal fin spine. A median dorsal projection forms a ring of bone which passes through a foramen on the large (second) dorsal spine (Fig. 20).

The proximal radial of the third pterygiophore is reduced in size relative to the first and second and forms a narrow strut supported basally by the sixth vertebra. Its cartilagenous dorsal extremity articulates with the cartilage distal radial of the second branched ray. There are four subsequent pterygiophores; each is progressively reduced in size and shares the support of two branched rays. The proximal radial of the last pterygiophore is biramous and supports the last branched ray. A cartilage distal radial is present between the divided base of each branched ray and the cartilagenous head of each proximal radial.

## *Pelvic fin skeleton (Fig. 21)*

Each pelvic bone is forked antero-laterally and has a broad medial plate which meets and forms a cartilagenous symphysis with the opposite unit. A slender cartilagenous ischial process is present. The fin rays articulate against a cartilage-capped posterior ridge. A short lateral splint, similar to that described by Gosline (1961) for many lower teleostean fishes, lies adjacent to the first ray.

## *Anal fin skeleton*

Apart from the first, the proximal radials of the anal fin are all simple and slender. The first proximal radial is a short heart-shaped plate providing an attachment surface for the bi-

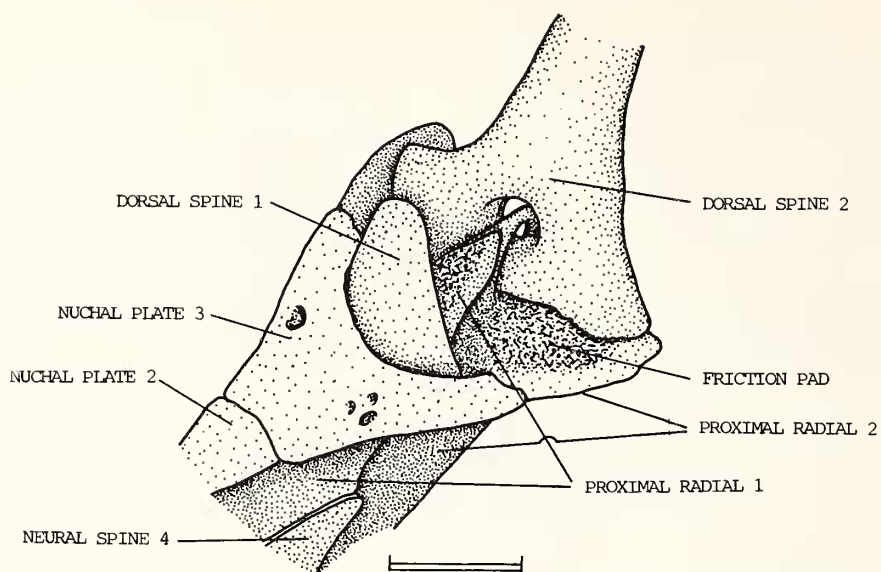


Fig. 20. Antero-dorso-lateral view of portion of dorsal fin skeleton of *Gephyroglanis barnardi* sp. nov. A ligament between dorsal spine 1 and 2 has been cut and the spines are separated more than is natural. Scale bar = 1 mm.

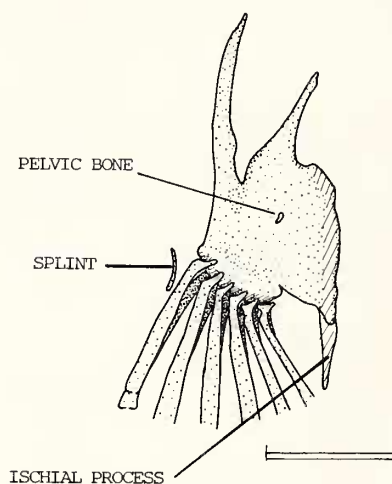


Fig 21. Dorsal view of left pelvic fin skeleton of *Gephyroglanis barnardi* sp. nov. Scale bar = 1 mm.

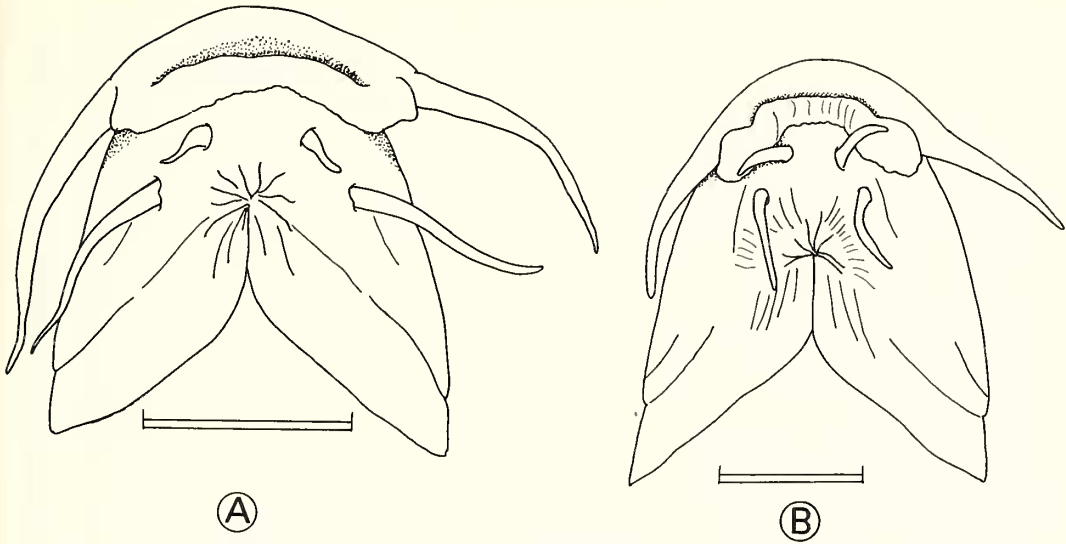


Fig. 22. Ventral view of head of A. *Gephyroglanis gilli* (AM/P 7646, 61 mm SL) and B. *Gephyroglanis sclateri* (AM/P 7840, 62 mm SL). Scale bar = 5 mm.

lateral blocks of the infracarinalis medius muscle running from the pelvic bones. The articulation end of each proximal pterygiophore terminates in a pad of cartilage. These pads articulate with cartilage spheres (the distal radials) located between the base of each fin ray. The unbranched fin rays are slender and flexible; only the small anterior-most two are unsegmented and none can be described as spinous. On account of the minute size of the first ray, accurate counts are not possible without clearing and staining. The branched rays are quadrifurcate except the anterior and posterior rays which are trifurcate.

#### DISCUSSION

There is little doubt on the morphological evidence presented above that there are two distinct *Gephyroglanis* species in the Olifants River system. A surprising outcome of the investigation is that Barnard, whilst fully aware of the two forms within his Olifants samples, did not perceive the real extent of the differences between them. Barnard's entire attention focused on the form of the fins, structures which are well known to be phenotypically influenced by the environment (Hubbs, 1941).

In addition to the array of anatomical characters on which the existence of the new species, *G. barnardi*, is recognized, the suggestion by Barnard (1943) that the two forms have different habitat preferences was tested in the field. Barnard (1943) indicated that the low fin form (= *G. barnardi*) preferred a sluggish muddy environment and the high fin form (*G. gilli*) preferred a stony swiftly flowing habitat. On a visit to the Noordhoeks River in January 1981 the author and Mr S. Thorne electrofished both species from the same stony bottomed, swiftly flowing stretch of river. Both species were taken from a site in the Thee River which, whilst rocky bottomed, had been obstructed by means of a rocky wall so that the current was sluggish and the rocks were covered by a layer of silt. In a third tributary, the Oudste River, at a site where the current was sluggish and the bottom was a mosaic of bedrock, scattered loose rocks, sand and mud and where the banks were undercut in a fine grained soil only *G. gilli* was



encountered. Similarly in the Boskloof River, a tributary of the Boontjies River, where the rocky bottom was covered by silt, only *G. gilli* was collected. In both the Boskloof and the Oudste localities *G. gilli* was taken both from amongst the rocks and from under the muddy banks.

It appears, therefore, that the correlation of fin form to habitat reported by Barnard (1943) is not upheld. In this regard it is interesting that seven specimens taken from an irrigation channel off the Jan Diessels River (SAM 22467) and reported by Barnard (1943) as being of the low fin form are in fact specimens of the high fin form recognized as *G. gilli*. The only low fin forms (*G. barnardi*) within the type series of *G. gilli* are seven specimens in SAM 19359 collected in February 1939 from the Noordhoeks River and the Olifants River at Keerom. These facts contradict Barnard (1943: 229) and it appears that either the samples were mixed up after collecting or that Barnard was confused in correlating specimens and localities. In the light of more recent collecting and observations as reported in the previous paragraph the latter explanation is the more likely. Furthermore, the author collected only *G. gilli* in the Jan Diessels River in January 1973.

A lectotype for *G. gilli* (SAM 29231) has been selected from SAM 22467 which is part of the original syntype series (of this species). The remaining specimens of the sample become paralectotypes as does the remainder of SAM 19359 after the removal of seven *G. barnardi* specimens. The seven *G. barnardi* specimens (SAM 29232) have been included as paratypes of the species. All the material of *G. gilli* and *G. sclateri* examined is recorded in Appendix 1.

The three southern African *Gephyroglanis* species (*G. barnardi*, *G. gilli* and *G. sclateri*) are geographically remotely isolated from other species of this genus. The key character on which Boulenger (1901) originally placed *G. sclateri* within *Gephyroglanis* is the absence of teeth on the palate (vomer). As pointed out by Roberts (1975) a loss character such as this is not necessarily synomorph and could easily (and possibly more likely) be a convergent or parallel development in such geographically remote species. Petric (1973; 1976) suggested that the manner in which the posterohyal articulated with the interopercle and the concomitant loss of the interhyal in *G. gilli* and *G. sclateri* was an unusual feature of these South African species. If this is so (the phenomenon does not appear to have been reported for other bagrid species) it would strongly suggest a synapomorphy and indicate at least that the southern species are monophyletic. Personal observations in the osteology of *G. gilli* and *G. sclateri* in the course of the present investigation have revealed that the interhyal is frequently present in both species, albeit in a vestigial form. The synapomorphy *per se* is not therefore negated which suggests that the generic identity of the South African *Gephyroglanis* species is open to question. The type series of this genus is *G. congicus* Boulenger, 1899, which inhabits the Zaire River.

In recording the above it should also be noted that the South African *Gephyroglanis* do not agree with all of Jayaram's (1966) points of definition of this genus. Firstly that author describes the snout as acuminate (narrow and pointed), however, the snouts of *G. gilli* and *G. barnardi* are rather obtusely blunt and rounded. Furthermore, although the snout of *G. sclateri*, a species examined by Jayaram, is more slender than that of *G. gilli* and *G. barnardi* it cannot be described as acuminate. Secondly the lips are recorded as thin and plain, however, they are papillose in *G. barnardi* and *G. gilli* and rugose in *G. sclateri*. The number of branchiostegal rays is smaller in the South African species than recorded for the genus by Jayaram (*viz* eight to ten); *G. sclateri* and *G. gilli* usually have seven on either side and *G. barnardi* six. Further research on the generic status of the South African species is in progress, and no change is made at this stage pending the outcome of the investigation.

The absence of gill rakers on the posterior border of the first and second gill arches is a difficult character to evaluate without more in- and out- group comparisons. The only reference to this character which has been traced in the literature is Harry (1935). In describing the

osteology of *Amphilius longirostris* (Boulenger, 1901) Harry (*op. cit.*: 216) recorded that there were gill rakers on the first four gill arches (ceratobranchials) and "In addition the third and fourth ceratobranchials bear a single row of eight stout spinous rakers on the inner face". Petrick (1976) did not record the gill-rakers of *G. sclateri* in his account of the osteology of the species. In both *G. sclateri* and in *G. gilli* the situation with regard to the absence of rakers on the posterior edge of the first two arches is, however, the same as that described above for *G. barnardi*. In addition to some amphiliids [Harry, 1953; pers. obs. on *Amphilius platyichir* (Günther, 1864), *A. natalensis* Boulenger, 1917 and *A. lampei* Pietschmann, 1913], the mocho-kids *Synodontis leopardinus* Pellegrin, 1914 and *Chiloglanis anoterus* Crass, 1960, also do not have posterior edge rakers on the first two arches (pers. obs.). The situation in other bagrids is evidently variable as *Chrysichthys hildae* Bell-Cross, 1973 and *Auchenoglanis ngamensis* Boulenger, 1911 have stout rakers on the posterior edge of the first four gill arches. *Gephyroglanis longipinnis* Boulenger, 1899 (MRAC 123287-288) has rows of knob-like rakers on the posterior edges of all the gill arches. *Gephyroglanis congicus* (MRAC 96639) has an equally elaborate series of branched rakers on the posterior edges of the gill arches. A complex distribution of the character is foreseen within the siluriformes which is likely to be closely correlated with functional demands.

A few preliminary comments on the inter-relationships of the three South African species can be made at this stage. Generally *G. barnardi* differs more from both *G. gilli* and *G. sclateri* than these two species do from each other, which is not in itself any indication of the phylogenetic relationships between them. Many of the distinguishing features of *G. barnardi* are apparently autapomorph: for example the relatively weak dorsal and pectoral fin spines; the small humeral process; the reduction in size of the nuchal shield and its connection with the supraoccipital.

The caudal fin skeleton possibly provides one synapomorphy for *G. barnardi* and *G. gilli* in that these two species have a greater degree of hypural consolidation than does *G. sclateri*. In *G. sclateri* the hypurals are generally free except for hypurals three and four which are fused basally. In *G. barnardi* and *G. gilli* hypurals one and two are fused or separate only in juveniles. In *G. barnardi* hypurals three, four, five and six are also fused. The degree of fusion shown by *G. barnardi* is greater than that shown by any bagrid species reported on by Lundberg and Baskin (1969). A few bagrids including *Gephyroglanis longipinnis* were found by these authors to have hypural three and four fused but only one species (*Chrysichthys ornatus* Boulenger, 1902) to have, in addition, hypurals one and two fused. The skeletal differences relating to the caudal fins of the three South African species are (coincidentally) correlated with the external forms of these fins: in *G. barnardi* the fin is truncate, in *G. gilli* emarginate and in *G. sclateri* forked. Lundberg and Baskin (1969) found that the majority of bagrid species they examined had B type hypurapophyses (the hypurapophysis and secondary hypurapophysis on hypural 1). The South African *Gephyroglanis* species appear to have an A type hypurapophysis. All specimens of *G. sclateri* and *G. barnardi* examined had an A type and of the three available specimens of *G. gilli* two had an A type, however, one had a B type. (A type: hypurapophysis on parhypural arch, secondary hypurapophysis on base of hypural 1).

A feature of the caudal fin skeleton of several catfish examined to date which appears to have been overlooked by Lundberg and Baskin (1969) is the presence of a third uroneural. This element is clearly present in *G. barnardi* albeit as cartilage. Its cartilaginous nature possibly explains why it was not found in other catfish by Lundberg and Baskin (*op. cit.*).

Monod (1968) illustrated the caudal skeleton of a *Gephyroglanis* species and included a cartilage "opistural" which is here interpreted as the third uroneural. This element is also clearly present in cartilage form in the schilbeids, *Schilbe mystus* and *Eutropius depressirostris* (AM/P 3121, 3256 and AM/P 742 respectively). It is difficult to detect in only alizarin red stained specimens, but has been found in both dry and alizarin preparations of *G. sclateri* and *G. gilli* (pers. obs.).

One character which contradicts the caudal fin synapomorphy of *G. barnardi* and *G. gilli* is the dorsal fin ray count. *G. barnardi* has usually six branched dorsal fin rays the number which is most common among other *Gephyroglanis* species (Boulenger, 1911; Jayaram, 1966) and other genera of the Chrysichthyinae (Jayaram, 1966). Based on an out-group comparison this appears to be the plesiomorph condition. *G. gilli* and *G. sclateri* both have seven dorsal branched rays, arguably synapomorph in the South African context. On the other hand it has been pointed out (Heemstra, pers. comm.) that the configuration of the last dorsal proximal radial (Fig. 18a) in *G. barnardi* suggests that the last ray has been lost. If this is so, then the possession of the seven branched dorsal rays of *G. gilli* and *G. sclateri* is the plesiomorph condition and is not indicative of a closer relationship to each other than either may have to *G. barnardi*.

The placement of the mandibular barbels is similar in *G. barnardi* and *G. gilli* but differs in *G. sclateri* (Figs 5;22). In the former two species the posterior mandibular barbels are lateral to the gular node and postero-lateral to the anterior mandibular barbels. In *G. sclateri* the posterior mandibular barbels are distinctly anterior to the gular node and lie more or less posterior to the anterior pair. The vertebral counts of the South African *Gephyroglanis* species are compared in Table 3. There is a broad overlap in counts between *G. gilli* and *G. barnardi*, however, *G. sclateri* has a larger count. This finding agrees with Lindsey's (1975) pleomeristic rule as *G. sclateri* attains twice the size of the other two species.

Jayaram (1966) separated *G. sclateri* and *G. gilli* chiefly on the basis of anal fin rays (*G. gilli* 11–13 v. 16–17 in *G. sclateri*). These figures were based on Boulenger (1901, 1911) and Barnard (1943) with the latter author dividing the rays into spines, simple rays and branched rays. Barnard's (1943) count for *G. sclateri* was 2–4, 2–3, 10–12, usually 4, 2, 12, with the total range 16–19. The count for anal fin rays given by Barnard for *G. gilli* was 2–3, 2, 10–11, most frequently 3, 2, 10, with a total range of 14–16 not 11–16 as given by Jayaram (1966). A comparison of anal fin rays of the three southern African species is given in Table 2. The formula for *G. barnardi* is III–VI, 10–13 (spines and simple rays not separately distinguished), most frequently IV, 11 with a total range of 14–18. *G. sclateri* is therefore generally characterized by more anal fin rays than either Clanwilliam Olifants species although this is not necessarily a diagnostic feature of every specimen. The South African *Gephyroglanis* species have a greater number of anal fin rays than other species of this genus (Jayaram, 1966), a fact which is noteworthy in terms of the general distinction already made of these three remote southern representatives.

The geographical distribution of *Gephyroglanis* species in the Orange and Olifants River systems, together with other freshwater fish species in these two systems, offers substantial support for the theory that the two systems were linked at some stage in the past (Jubb & Farquharson, 1965; Skelton, 1980). Fryer (1977) also suggested such a link on the evidence of the distribution of related species of the ectoparasitic crustacean genus *Chonopeltis*. Two factors suggest that this link is likely to have been a relatively ancient one, probably pre-Pleistocene. These are the high degree of endemic speciation of the fish species concerned in both the Orange and the Olifants, and secondly that there is little direct present day geological indication of such a link.

#### ACKNOWLEDGEMENTS

The research was funded by the Department of Nature and Environmental Conservation and was stimulated by collections received from two officials of that department, Mr K. Hamman and Mr S. Thorne. Assistance was given by Mr S. Thorne and Mr A. Welman. The manuscript was kindly read and criticized by Mr W. Holleman and Dr P. C. Heemstra.



# SKELTON: DESCRIPTION AND OSTEOLOGY OF GEPHYROGLANIS

## REFERENCES

- ALEXANDER, R. McN. 1966. Structure and function in the catfish. *J. Zool., Lond.* **148** (1): 88-152.
- BARNARD, K. H. 1943. Revision of the indigenous freshwater fishes of the S.W. Cape region. *Ann. S. Afr. Mus.* **36** (2): 101-262.
- BOULENGER, G. A. 1901. Description of a new Silurid fish of the genus *Gephyroglanis*, from South Africa. *Ann. S. Afr. Mus.* **2** (8): 227-228.
- BOULENGER, G. A. 1911. *Catalogue of the Fresh-water fishes of Africa in the British Museum (Natural History)*. Vol. 2. London. British Museum (Natural History).
- CHARDON, M. 1968. Anatomie comparée de l'appareil de Weber et des structures connexes chez les siluriformes. *Annls Mus. r. Afr. cent. Sér. 8vo., Sci. zool.* **169**: 1-277.
- FRYER, G. 1977. On some species of *Chonopeltis* (Crustacea: Branchiura) from the rivers of the extreme South West Cape region of Africa. *J. Zool., Lond.* **182**: 441-445.
- GAIGER, I. G. 1978. *The distribution, status and factors affecting the survival of indigenous freshwater fishes in the Cape Province*. Research report, Cape Provincial Department of Nature and Environmental Conservation. pp. 74-128.
- GOSLINE, W. A. 1961. Some osteological features of modern lower teleostean fishes. *Smithson. misc. Collns* **142** (3): 1-42.
- HARRY, R. R. 1953. A contribution to the classification of the african catfishes of the family *Amphiliidae*, with description of collections from Cameroon. *Revue Zool. Bot. afr.*, **47** (1-2): 177-232.
- HUBBS, C. L. 1941. The relation of hydrological conditions to speciation in fishes. In: *A symposium on Hydrobiology*. Madison. Univ. Wisconsin Press, pp. 182-195.
- HUBBS, C. L. and LAGLER, K. F. 1958. Fishes of the Great Lakes Region. *Bull. Cranbrook Inst. Sci.* **26**: 213 pp.
- JAYARAM, K. C. 1966. Contributions to the study of the fishes of the family Bagridae 2. A systematic account of the African genera with a new classification of the family. *Bull. I.F.A.N. Sér. A* **28** (3): 1064-1139.
- JUBB, R. A. 1967. *The freshwater fishes of southern Africa*. Cape Town. Balkema.
- JUBB, R. A. and FARQUHARSON, F. L. 1965. The freshwater fishes of the Orange River drainage basin. *S. Afr. J. Sci.* **65**: 118-125.
- LINDSEY, C. C. 1975. Pleomerism, the widespread tendency among related fish species for vertebral number to be correlated with maximum body length. *J. Fish. Res. Bd Can.* **30**: 409-434.
- LUNDBERG, J. G. 1975. Homologies of the upper shoulder girdle and temporal region bones in catfishes (Order Siluriformes), with comments on the skull of the Hologeneidae. *Copeia* 1975 (1): 66-74.
- LUNDERG, J. G. and BASKIN, J. H. 1969. The caudal skeleton of the catfishes, order Siluriformes. *Am. Mus. Novit.* (2398): 1-49.
- MONOD, T. L. 1968. Le complexe urophore des poissons téléostéens. *Mem. d'Inst. Fond. d'Afr. Noire* (81) 1-705.
- NELSON, G. J. 1969. Gill arches and the phylogeny of fishes with notes on the classification of vertebrates. *Bull. Am. Mus. nat. Hist.* **141**: 479-552.
- PATTERSON, C. 1975. The braincase of pholidophorid and leptolepid fishes, with a review of the actinopterygian braincase. *Phil. Trans. R. Soc. Ser. B.* **269**: 275-579.
- PETRICK, F. O. 1973. An anomaly in the hyoid arch of *Gephyroglanis sclateri* Boulenger and *Gephyroglanis gilli* Barnard. *News. Lett. Limnol. Soc. South Afr.* (21): 37-38.
- PETRICK, F. O. 1976. *The anatomy of the freshwater fishes of the Transvaal VIII Gephyroglanis sclateri*. Typescript report to Provincial Fisheries Institute, Lydenburg. As revised (1976). 39 pp. 30 figs.
- ROBERTS, T. C. 1975. Geographical distribution of African freshwater fishes. *Zool. J. Linn. Soc.* **57**: 249-319.
- SKELTON, P. H. 1976. Preliminary observations on the relationships of *Barbus* species from Cape coastal rivers, South Africa (Cypriniformes: Cyprinidae). *Zool. Afr.* **11** (2): 399-411.
- SKELTON, P. H. 1977. *South African Red Data Book: Fishes*. (South African National Scientific Programmes, Report No. 14.) Pretoria. CSIR.
- SKELTON, P. H. 1980. *Systematics and Biogeography of the redfin Barbus species (Pisces, Cyprinidae) from southern Africa*. Unpubl. Ph. D. Thesis, Rhodes University, Grahamstown, South Africa.
- TAYLOR, W. R. and VAN DYKE, G. C. 1979. *Revised procedures for staining and clearing small fishes and other vertebrates for bone and cartilage study*. Manuscript report, National Museum of Natural History, Washington, 21 pp.
- WEITZMAN, S. H. 1962. The osteology of *Brycon meeki* a generalized characid fish with an osteological definition of the family. *Stanford ichthyol. Bull.* **8** (1): 1-77.

Manuscript accepted for publication 2 March 1981.